Forestry

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LEO C. MASSOPUST,
EDITOR

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The Journal of the Biological *Photographic* Association

Official Publication of the Biological Photographic Association

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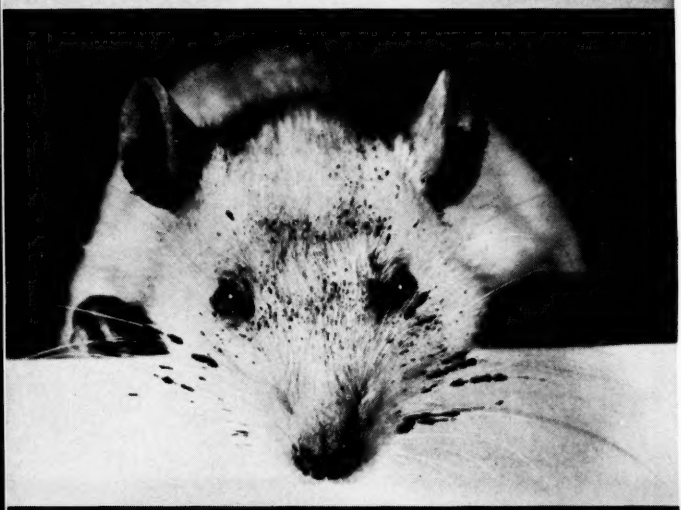
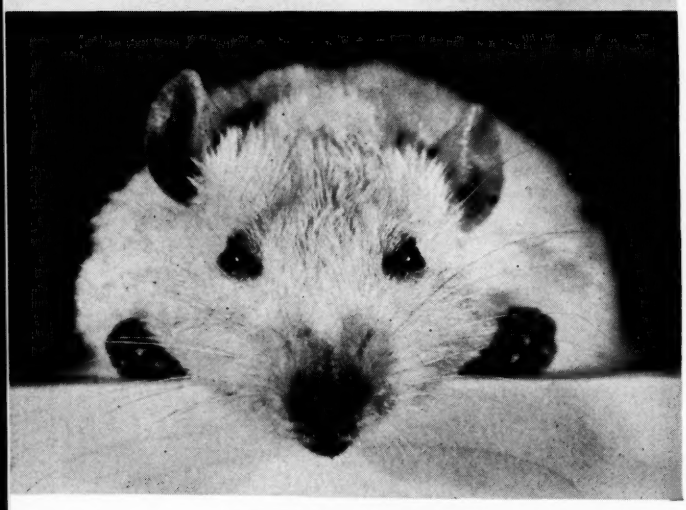
Rusty head and bloody whiskers rat. Characteristic of riboflavin deficiency 8/8/41.



Improvement after 8 days on 100 γ riboflavin supplement.



Rat cured — 25 days on riboflavin supplement 9/2/42.

Film, Eastman Super Speed Ortho 5 x 7; Exposure, 20 seconds at F 32; Developer, D 19, printed D 72 Kodabromide; Lights, two No. 4 Photofloods. In order to obtain this series of photographs it was necessary to work within six inches of the subject with an F 4.5, 21 cm. lens. The long exposure and good depth of focus obtained by anesthetizing the rat with sodium amytal. (Photograph by Howard Kothe, The Fleischmann Laboratories of Standard Brands Incorporated, New York City, New York.)

Routine Color Photography of the Cervix Uteri

by Wilson Footer, M. D.*

PHOTOGRAPHS in color of the cervix uteri are valuable in following lesions of this organ and in illustrating such lesions to students. However, the literature contains very few actual photographs of the cervix due to the difficulties inherent in taking them.

During the past seven years this problem has been approached in various ways. In the first articles on the subject Creer[1] and later Creer and Kimble[2] described an apparatus consisting of two small bulbs attached to the inside of a blackened bivalve speculum. Three cameras were tried; 1, a 5 x 7 inch clinical camera; 2, a 3¼ x 4¼ inch Auto Graflex; 3, a 2¼ x 3¼ inch Zeiss Icon. These were mounted on a tripod. They used Eastman superspeed portrait film, a six inch lens and an exposure of two seconds at f: 8. Later Kimble[3] published an article containing sixteen photographs of cervices before and after treatment for chronic cervicitis.

Bruner, Rosebrook and Cushman[4] devised special tubular specula of metal 1½ and 2 inches in diameter. Two radio dial lights were mounted on a separate ring which fastened over the outer end of the speculum after the obturator had been removed. A Leica camera mounted on a tripod was then aligned with the speculum at a distance of 8 to 10 inches. Exposures were 3 to 5 seconds using Eastman "background" film. His article contains six excellent black and white photographs of the cervix.

Galloway[5] mounted one "Good-Lite" on each side of a Leica camera which in turn was attached to a miscroscope stage for focusing. A Speed-o-Copy was used to check the focusing. This assembly was attached to a standard by a universal ball joint. The cervix was exposed with a blackened bivalve speculum with Penrose drain over the blades to keep the vaginal walls from obstructing the view. The 90

* Richmond Field Hospital, Richmond, California. Received for publication March 25, 1943.

mm. f: 4.5 lens was used at 18 cm. from the cervix. Exposure were 4/5 sec. at f: 9. Five to ten minutes were required to assemble and take a photograph with this apparatus. No examples of the work done were published with this description. A similar type of instrument is described in Herrera's article[6].

Hull[7] used a bivalve speculum, with special lights built in, to which the camera and ground glass copying attachment are mounted by a focusing microscope stage. In use this instrument is supported either manually or on a tripod. Exposures with Kodachrome Type A at f: 12.5 varied from ½ to 1/20 of a second. This is the only apparatus described in the literature in which the speculum, lights and camera are mechanically aligned during operation. It is entirely satisfactory for occasional photography but when used consecutively on different patients the camera must be dismounted and the speculum with the attached microscope stage sterilized each time. The alternative would be to use several of these in rotation but this would increase the bulk and cost of the equipment.

Fallon, Brosnan and Moran[8] exposed the cervix with tenacula and four or more retractors. This of course required assistants. Photoflood bulbs were used for illumination. Their camera was mounted on their regular photographic truck which was used for other types of clinical photography.

All of these methods have certain limitations which restrict their routine use in a busy clinic or practice. Primarily they are time consuming and should be used by someone with at least some knowledge of photography. With the exception of Hull's apparatus the camera must be placed in the axis of the speculum at a distance from it. Any subsequent motion of the patient or the camera necessitates readjustments. With Hull's unit the assembly must be dismounted for sterilization of the speculum and focusing stage before the next patient can be photographed.

To overcome these drawbacks the present equipment has been constructed (fig. 1, 2 and 3). A Kine-Exakta, a 35 mm. true reflex camera, is used because the focusing is controlled up to the instant the picture is snapped. This also eliminates the procedure of removing a copying ground glass attachment and swinging the camera up to position, causing both delay and possible inaccuracies in focusing.

The lens most frequently used is the 50 mm: f: 2.8. With this the film image is about 8 mm. in diameter, sufficient for direct viewing or for projection. With the diaphragm wide open and an exposure of 1/25 second on Kodachrome Type A film the picture has sufficient sharpness

and depth. The other lens is a 120 mm. telephoto f: 6.3. This gives a picture 18 mm. in diameter, an advantage when recording minute lesions. To compensate for the shallow depth of focus due to the longer

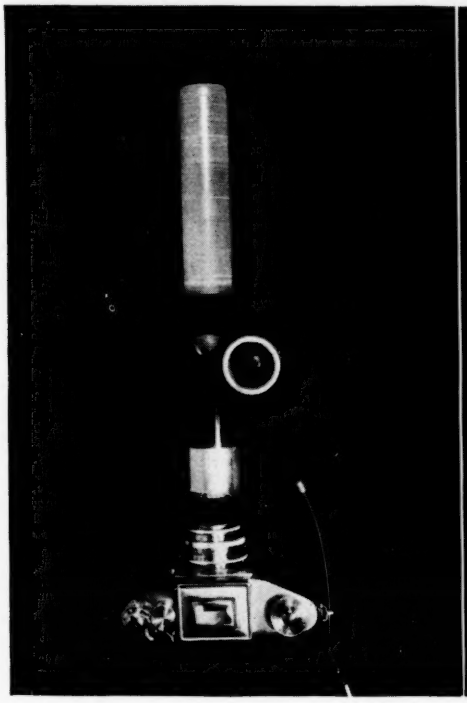


Fig. 1. Component parts. The lucite speculum is at the top.

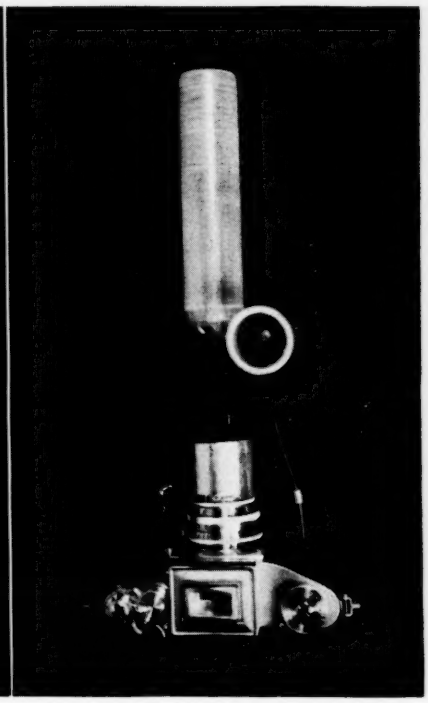


Fig. 3. Arrangement of camera, light and speculum when in use.

focal length of this lens it is stopped down to f: 10, which requires ½ second exposure.

Illumination is provided by a special apparatus which connects the speculum and camera. It consists of a 4 inch section of 1½ inch tube with a hole in its side near its distal end. Outside this is a tubular housing containing a 100 watt projection bulb and reflector insulated from the rest of the assembly to prevent possible shock to the patient or operator. The light shines through the opening in the main tube and is reflected in its axis onto the cervix by a mirror with a hole in its center. Light from the cervix passes back through this opening to the

lens at the proximal end of the tube and into the camera lens. The same accessory lens is used with both the 50 mm. and 120 mm. lenses. It is planned to increase the efficiency of the light unit by using a 200 watt bulb, with a double wall housing for the bulb to prevent overheating of the outside of the apparatus.

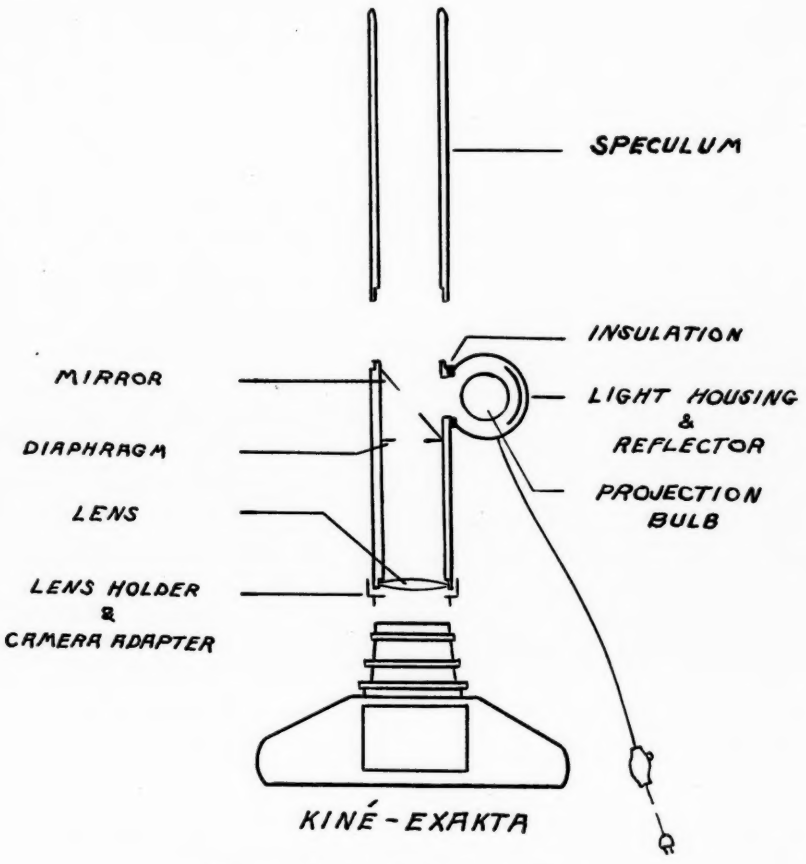


Fig. 2. Diagram illustrating Fig. 1.

Three specula have been tried; 1, bivalve with and without Penrose drain; 2, special lucite tubular speculum; and 3, Fergusson silvered glass speculum. The bivalve speculum has now been discarded because it is less easily handled, does not reflect light uniformly and, most important, does not permit alignment of the complete apparatus while taking the picture. The lucite speculum was so constructed that the

distal end of the light adapter fit securely into it but could be readily disconnected by a slight twist. The Fergusson speculum gave the best results because it reflected more light and reflected it more uniformly onto the cervix. However, this speculum does not permit joining the light adapter to it. To incorporate the advantages of both the lucite and Fergusson specula for photographic purposes, a speculum is to be constructed consisting of a metal tube acting as a sheath for a silvered glass tube. The outer end of the metal portion will provide attachment for the light unit.

When it is advisable during the examination of a patient to record the condition of the cervix or vaginal wall, exposure is obtained with the tubular speculum. When visualization is difficult with this it is sometimes easier to insert a bivalve speculum, expose the area to

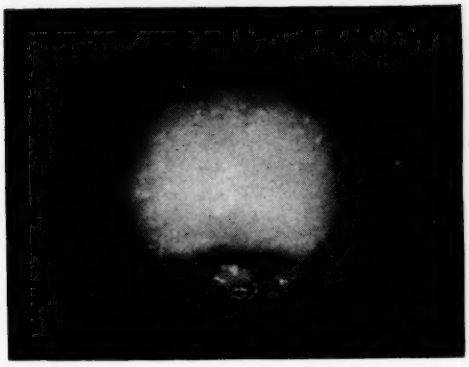


Fig. 4. Enlargement of 35 mm. Kodachrome transparency showing the cervix in a case of chronic gonorrheal endocervicitis. The original diameter of the photograph of the cervix on the transparency was 18 mm. Considerable sharpness and contrast have been lost in the process of reproducing this photograph in black and white.

be photographed, and with the bivalve speculum still in the vagina to insert the tubular speculum through it. The area is cleaned with a gauze sponge or cotton applicator unless the secretions are significant. The camera with the light adapter attached is connected to the end of the speculum, the light turned on, the focus checked and the picture snapped. With several specula available there is no delay from one patient to the next.

Even better photographs of the cervix may be obtained on those patients undergoing surgery because then the cervix may be exposed with retractors and brought close to the outlet by tenacula placed laterally upon it[8]. Under these conditions an R2 photoflood bulb is placed on either side of the camera which is equipped with the 120 mm. lens. Exposure is then obtained from the exposure meter reading.

It is often desirable in the same patient to photograph both the cervix and vulva as for instance in a case of trichomonas vaginitis when we may want to show the appearance of the discharge at the introitus and the cervical and vaginal lesions. Depending upon what is to be portrayed the vulvar picture may be taken either before or after the cervical picture. To obtain pictures of the vulva it is only necessary to separate the camera by a twist from the light unit, slip on an accessory lens and use one or two photoflood bulbs for illumination. This procedure is exactly the same as when photographs are taken during surgery of the cervix delivered by instruments to the introitus.

The previously reported methods for photographing the cervix are reviewed. A method is presented which simplifies this procedure so that it can be carried out routinely in either clinic or office practice.

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Kodachrome Photomacrography of The Eye

by Henry Roger*

FOR the diagnosis of various conditions of the human eye slit lamps, as manufactured by a number of well-known optical concerns, are being used extensively and are in fact standard equipment of every ophthalmologist and every hospital.

The slit lamp usually consists of a light source, in the form of a single coil filament incandescent lamp, or in some cases of a miniature arc lamp, a condensing system, an adjustable slit, an aplanatic aspherical lens, and an optical bench on which these parts are mounted. This illuminating system is generally used at an angle to the optical axis of the eye so as to illuminate the tissue sideways while this is being examined from the front with the aid of a binocular microscope.

Both slit lamp and microscope are parts of an equipment consisting of a glass top table on which the horizontally positioned microscope may be easily moved about and focussed on part of the patient's eye, a movable arm on which the slit lamp is mounted in such a way that it can be used on either side of the patient and at all practical angles, and can be adjusted at various heights.

Another part of the equipment is an adjustable head and chin holder attached to the table on the side of the patient.

The image as viewed through the microscope is of sufficient intensity and clarity for the examination of details at various magnifications ranging from about 10X or lower to 50X. The intensity of the light source may be varied within limits and in most cases is tolerated by the patient. It should be mentioned here that the heat emitted by the light source is usually reduced to a minimum by heat absorbing glass filters, which are part of the equipment, being placed in the beam of the illuminating system.

To make permanent photographic records, however, the light intensity of the slit lamp and of the image respectively formed by the

* From the Rolab Photo-Science Laboratories, Sandy Hook, Conn.
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optical system of the microscope is far below the threshold value of any photographic emulsion in view of the necessarily short exposures, counted only in fractions of seconds.

Some time ago a problem presented itself which involved the making of color photographs of the eye as seen by slit lamp illumination in order to show various stages of vitamin A and B2 (Riboflavin) deficiencies. Obviously the low light intensity of the slit lamp presented a real problem. Further difficulties also arose by the fact that no slit lamp was available for preliminary experiments due to the present emergency. However, the apparatus described below was constructed to overcome the difficulties. The instrument was assembled from parts on hand in our laboratories, and others which had to be designed and constructed in our workshop.

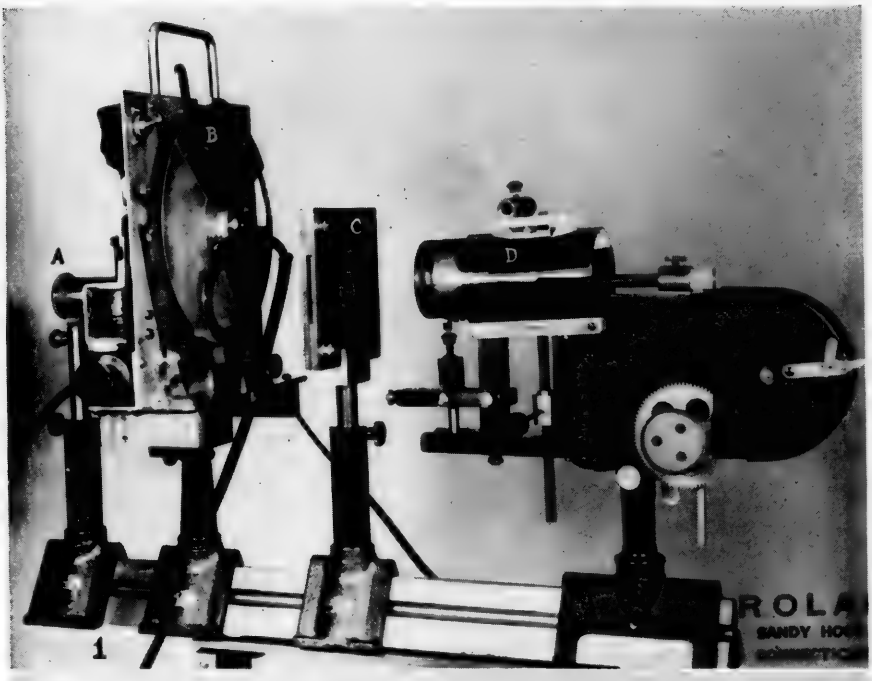
The light source consists of a re-built high intensity arc lamp which burns with ordinary intensity during examination and focusing. During the split-second exposure the intensity is boosted by special resistances, in the form of heating elements, shunted across the lamp rheostat. The current supply is D. C. for better arc lamp efficiency.

A special condensing system attached to the lamp is adjustable to focus an intense circle of light upon a slit which is part of the optical system as mounted on the optical track. The slit was made in the workshop and is of the precision type as used in spectroscopes. It can be used vertically as well as horizontally.

A novel shutter assembly is the next part. It consists mainly of a round disc with a sector cut out to which an adjustable blade was added, thus forming an adjustable sector opening. The disk has another round opening which is covered by a heat absorbing glass filter, a heavy neutral density filter, and a copper screen of fine mesh, which, in addition to the glass heat absorber, helps to dissipate the heat; it too, cuts down the light intensity. It is to be noted that only a fraction of the light intensity is used for focusing, being approximately the same amount as used in the ordinary slit lamp, and as said before, can be tolerated by the patient without discomfort. Additional parts of this shutter assembly are: a heavy duty mercury switch for the light booster, and a solenoid for tripping the shutter in synchronism with the camera.

The final part of this slit lamp unit consists of an objective which projects an image of the slit into the eye of the patient.

The camera, also of special design, is of the reflex type with a first surface mirror in its interior. During focusing the image is thrown upward by this mirror and then back by means of a right angle prism,



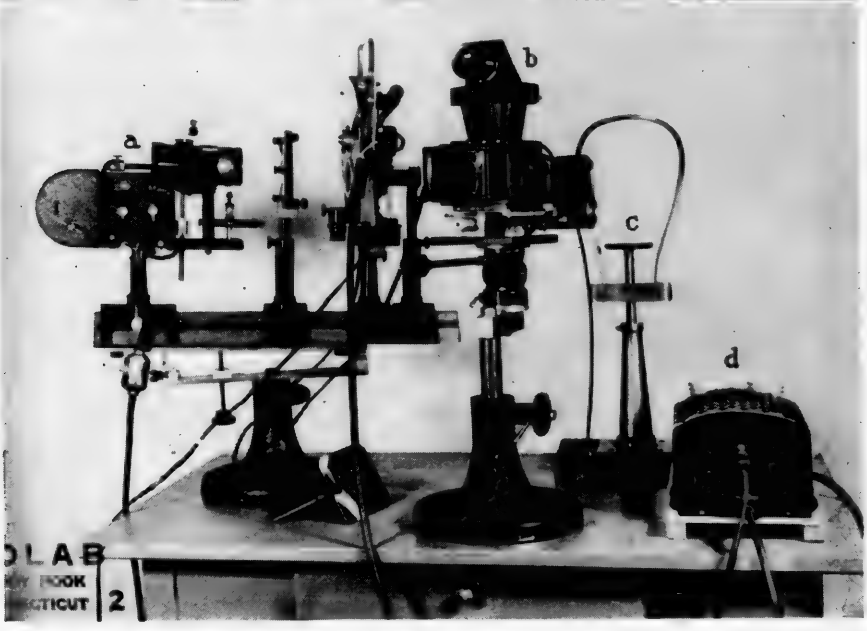


Fig. 1. Slit lamp assembly with shutter synchronized with camera. A, objective; B, synchronized shutter; C, slit; D, special arc lamp.

Fig. 2. Equipment for photomacrography of the eye. a, slit lamp assembly; b, special camera; c, head and chin holder; d, rheostat.

then picked up by a large eye piece. Apart from the binocular vision, examination and focusing is accomplished in the same manner and with equal convenience as with ordinary slit lamps. The film is exposed by a wire release which is usually attached to the pan and tilt handle of the camera stand. Focusing is done by rack and pinion with a large knob for speedy action. Micrometer focusing is also possible by moving the entire camera back and forth by means of a screw. One side of the camera carries an attachment with contacts for the electric release of the rotating shutter on the slit lamp. Another feature which has been added is a flash bulb holder and reflector for synchronized flash exposures, convenient for the photography of the entire eye, or eventually of other subjects. An advantage of this particular arrangement is the fact that the holder with reflector, which incidentally can also be used with ordinary Mazda lamps, travels back and forth together with the camera, thus remaining centered upon the area at all camera positions. This particular camera, being an experimental model, has adapters to hold single plate or film holders, and miniature cameras minus their objectives, such as the Bantam, the Contax, and others.

The chin holder is of the usual construction as used on ophthalmic instruments, except perhaps that it has its own heavy stand and can therefore be placed on any table. Its height is adjustable within practical limits.

Slit lamp as well as camera have their own individual heavy bases. All three units may thus be used on any small table usually found in a laboratory or office. It facilitates transportation from one place to another, also storage when not in use.

The optical equipment on the camera for this type of Kodachrome photography is about the same as used in low power photomacrography. Objectives of focal lengths from 25 mm. to 80 mm. are used corresponding to those regularly employed on the binocular microscope, the difference being that the objectives are corrected for photography. Magnifications on the ground glass range from 2.5X to 10X, which would correspond to visual magnifications of about 10X to 47X.

Stereophotography, Near Objects and Stereoprojection

by John A. Maurer*

THIS paper is particularly concerned with the problems of extreme close-ups, stereophotographs, and stereoprojection. The literature on stereophotography of near objects is rather scattered and not very extensive. There is considerable variation in recommendations as to the best lens separation for the two views in making stereophotographs at closer distances. If the interocular space of the eyes of two and a quarter to two and three fourths inches be used as the lens separation for the two stereo views of extreme close-ups or macrophotography, the resultant stereos are beyond the ability of the eyes to fuse a usable image. This fusion difficulty appears to be much greater for the projected image than it is with the ordinary handheld stereoscope. Since recommendations in the literature are not always applicable, and since the use of the natural interocular distance may produce undesirable results, the stereophotographer is faced with the problem of deciding what inter-lens distance should be used for widely varying conditions in close-up stereophotography. The problem has been attacked by trying to reconcile the variations in recommendations in the literature and then trying a number of variations on the same and various subjects. The trials were compared to ascertain a method of calculating lens separation for different subject conditions. The result is a practical system for making stereo-macrophotographs regardless of the scale of the photograph or the subject proportions.

We have found by our trials that the following factors must be taken into consideration in determining camera inter-ocular distance:

1. Desired viewing effect of enlargement or diminution in size of object.
2. Stereoscopic relief desired.
3. Relationship between picture size and viewing distance.

*Photographic Department Loyola University, School of Medicine, Chicago, Illinois. Received for publication January 10, 1943.

4. Absolute depth of object.
5. Absolute distance of object.

If the camera inter-ocular distance (lens separation) is varied from that of ordinary eye separation, then the apparent scale of the stereo will vary. Greater separation will give the appearance of nearby small models, while lesser separation will give the appearance of farther off enlarged objects. Since most of the subjects will be small objects enlarged on the screen, the lesser separation will result in an appearance on the screen of an enlarged model of the object. As most lantern slides of such subjects give the appearance of enlarged objects or models, we may accept this as being satisfactory. Working then with a reduced separation will fit in very nicely.

In conversation with Mr. Martinsen (see his article in a previous issue) the suggestion was advanced that adherence to some of the formulas for close-up work would produce undesirable results, especially for projection viewing. These formulas seem to be adjusted to give the maximum separation that the eyes can fuse. As a result all subjects both thick and thin seem to be of equal depth. Where the proportions of the objects are known to the viewer, the result would appear distorted in relative depth. Practical results indicated the essential truth in Mr. Martinsen's suggestion. Some correlation is then needed between the fusion power of the eyes, the relative depth of the subject, and the distance of the subject from the camera lens.

One limitation that seemed to stand out very strongly in all of the results was that the desirable stereoscopic plasticity or depth on the screen was obtained with only about one half to one fifth the relative camera lens separation that could be used in the hand stereoscope viewer. It is very evident that for stereoprojection views, large separations produce strong stereo effects which cannot be used on thick subjects without straining the eyes or the credulity or both. In this connection several sets of photographs were made of a frog. Where too great an inter-ocular distance was used the remarkable frog appeared to be several times as thick as he was wide. This effect was noticed only on projection and not when viewing the same transparency in a small hand stereoscope. Possibly this difference is related to the eye-viewing angle for the hand viewer and the screen projection. In viewing on the screen, the observer is relatively further away from the picture than when using the hand viewer. Thus for the hand stereo the eyes are about one to two diagonals of the picture away, while on the screen the eyes of the observer are two to ten diagonals distant from the image. It was noticed that the apparent depth of any projected stereo picture decreased when

approaching the screen and increased when moving away from the screen.

In this study, various subjects were photographed in stereo and the technical data of taking the same were recorded. In some cases a series of different interocular camera distances were used on the same subject. The results were viewed at a meeting of the Chicago Chapter of the BPA. There was general agreement among the members that the projected image gave greater depth than the hand viewer, but the most desirable amount of stereoscopic effect for a particular subject varied some with different observers. There was also some discussion as to how much effect different focal length lenses used on the same subject for the same area of subject would have on the final stereo. It was agreed that at least there would be some of that perspective effect that is present in ordinary photographs taken with different focal length lenses.

Based on the previous experience, the following suggestions are made. These suggestions should be used with discretion and where necessary adjusted by trial for specific problems. The values suggested will generally give a slight desirable increase in the stereoscopic effect but not the maximum stereo effect that the eye can fuse in a hand stereoscope. The table is particularly applicable to projection work.

TABLE I.

Subject depth divided by distance to nearest point in the view.	Lens separation in terms of the distance to the nearest point in the view.	Approximate equivalent rotation.
2:1 (200%) or deeper	1/50	1° 8′
1:4 (25%) or deeper	1/40	1° 26′
1:10 (10%) or deeper	1/30	1° 55′
1:30 (3%) or deeper	1/20	2° 52′
1:100 (1%) or deeper	1/10	5° 44′

To use this table for a subject in which the nearest point is 10 inches and the furthest point is 11 inches (10% more), the camera is moved sideways with respect to the line of view 1/30th of 10 inches or about 1/3rd of an inch. If done by rotation instead, the subject would be rotated about 2° between photographs, or else the camera would be rotated about the subject as a center for an angle of 2° In figuring depth the background distance would have to be included in the subject depth if it shows texture or pattern of any kind. The distance of a smooth even black, white or grey background without shadows may be neglected and the object will appear to float in space. The lens stop used should be one that will give clear sharp results. It is

suggested that your depth of focus should allow a confusion circle of not over 1/1000th of the diagonal of the picture and preferably even smaller.

The persons contributing stereophotographs to this study were, Mr. Adolph Lonert, Mr. James B. Glaze, Miss Avis Gregersen, Mr. William L. M. Martinsen and Mr. Maurer. The stereophotographs were mounted and finally prepared for projection by the Society for Visual Education.

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Dr. Vannevar Bush John T. Rule	Chapter on Stereophotography in Handbook of Photography
Dr. J. Moir Dalzell	Practical Stereophotography
Arthur W. Judge	Stereoscopic Photography
Clerc (Brown's translation)	Photography Principles and Practice.

THIRTEENTH ANNUAL MEETING

Although the September Journal usually comes out fairly early in the month, the difficulties of publication under war conditions may delay it, therefore, there is no use making announcements about a Convention that may be over before this number reaches you. Look in your December Journal for a report of the transactions of 13th Annual Meeting, which takes place in Princeton, N. J. under the Chairmanship of Mr. Julian Carlile, Rockefeller Institute for Medical Research, Princeton, N.J.

Photographic Processing Control

by Louis Paul Flory*

Part III

IV. Chemical Control. D. and E. *(continued)*

2. Rinse or Stop Baths

a. Negative rinse baths. Although it is not customary to use a rinse or stop bath in processing negatives in this laboratory, with the exception of motion picture film processing, recent work by Crabtree, Eaton, and Muehler[16] shows that a rinse bath is desirable when using certain types of fixing baths. If a rinse bath is used, control methods described under *positive rinse baths* may be applied.

b. Positive rinse baths. The functions of the rinse bath are: to stop development of the print; prevent staining of prints by oxidation products of the developing bath; prevent carry-over of alkaline developing products to the fixing bath which would lower the acidity (increase the pH) of the fixing bath, possibly causing precipitation of aluminum sulfite in a potassium alum fixing bath.

The acidity of the rinse bath, therefore, is used as the criterion in measuring the useful life of the bath. Other conditions, such as sludging or discoloration, may necessitate discarding the bath while it is still acid. Loss of solution by carry-over and evaporation may make it desirable to discard the bath. All these factors must be taken into consideration in determining the useful life.

An acid rinse bath (Eastman Kodak SB-1) with an acetic acid concentration of 0.24 Molar, and a pH of 3.0 when fresh, is used in this laboratory when processing paper prints. The prints are rapidly rinsed in running water between the developing bath and the acid rinse bath. This water rinse prolongs the life of the acid rinse bath, for it removes some of the alkaline developing bath which remains on the surface of the prints after they are removed from the developing bath. It should be used if equipment and space make it possible.

* From the Boyce Thompson Institute for Plant Research, Yonkers 3, New York. Received for publication August 2, 1943.

[16] Crabtree, J. I., G. T. Eaton, and L. E. Muehler: "The Removal of Hypo and Silver Salts from Photographic Materials as Affected by the Composition of the Processing Solutions." Journal of the Society of Motion Picture Engineers. Vol. XLI (July, 1943), pp. 9-68.

The rinse-bath-processing tray used in this laboratory (Pako rocker system) has a capacity of 12.6 liters, and the useful life of the bath, calculated from published tables, should be approximately 568 five by seven inch prints per batch of rinse bath. This figure is not realized in this laboratory for some of the reasons mentioned above, and in most cases the bath is discarded while still acid—usually at a pH of from 3.8 to 4.2. Table I shows little correlation between the pH and the number of prints processed. In the absence of other factors, the pH of the bath should be used in determining when to discard the bath. A method of measuring the pH of rinse baths will be discussed in detail in Appendix D, to be published in Part IV.

TABLE I

Bath No.	No. of Prints (5 x 7", single weight)	pH
1	118	3.8*
2	188	4.0*
3	100	3.4
3	281	4.0*
4	88	3.9
4	285	4.2*

* discarded at this value

The silver concentrations, in grams per liter, of the above rinse baths were measured and found to range from 0.006 to 0.05. Such concentrations are insignificant. It has also been shown[16] that the composition of the rinse bath has no appreciable effect in retarding or hastening the washing of photographic material when the EK F-5 fixing bath was used.

In some laboratories it is customary to place a print in the fixing bath for a short time after rinsing in the acid rinse bath to remove the unexposed, undeveloped silver halide. This removes the yellow surface color—prevalent in bromide papers used in projection printing—which interferes with the judgment of the extent of exposure and tonal values of the print. After inspection, the print is usually returned to the rinse bath to be processed along with the rest of the prints. This procedure shortens the useful life of the rinse bath. A small amount of fixing bath is carried over on the print and goes into solution in the rinse bath which contains an excess (relatively) of acid. The sodium thiosulfate in the carry-over in the presence of the excess of acetic acid causes a precipitate to form. This precipitate contains an

appreciable amount of sulfur which will be retained by the print emulsion and will not be removed in the subsequent fixing and washing. The presence of sulfur will cause the print to "fade" at some future date.

If it is necessary to place a print in the fixing bath to expedite inspection, the author recommends that the print be left in the fixing bath instead of being returned to the rinse bath. The print may be processed separately, or left in the fixing bath to be processed along with the prints which will subsequently be transferred from the rinse bath to the fixing bath. The total fixing time of any print, however, should not be excessive if a permanent print is desired[16].

Records should be kept of the number of prints processed in each batch of rinse bath, together with the pH value of the bath. Measurements of pH should be made daily if the quantity of prints processed is 100 or more. Regardless of the pH value, the rinse bath should be discarded upon the first sign of discoloration or sludge. If these do not occur, the pH at which the bath should be discarded will depend upon the type of prints and the processing conditions in each laboratory.

3. Fixing Baths

a. Negative fixing baths. This laboratory has been using the Eastman Kodak F-5 fixing bath, containing 10 grams of sodium sulfite per liter, for fixing negatives since its introduction by Russell and Crabtree[17] in 1933. Recent investigations[16] may make it desirable to use the more recent EK F-6 formula, but the control methods used in determining the useful life of the fixing bath will remain the same.

There are two functions of a fixing bath: to harden the emulsion, protecting it from damage during subsequent handling; to remove the unaffected silver from the emulsion. These functions may be measured by measuring the pH and the concentration of silver in the bath, giving an indication of the useful work performed by the bath.

The pH of a fixing bath is the measure of the useful life of the bath with respect to its hardening properties. Russell and Crabtree (op. cit.) mention a method of determining the useful life of the F-5 fixing bath, using brom cresol purple (dibromo orthocresol sulphone phthalein) as an indicator of the pH value. This method is a subjective one, and the author prefers the more objective method—using a hydrogen-ion comparator and employing brom cresol green (dibrom-m-cresol sulphone phthalein) or brom cresol purple as indicators,

[17]Russell, H. D., and J. I. Crabtree: "An Improved Potassium Alum Fixing Bath Containing Boric Acid." Journal of the Society of Motion Picture Engineers. Vol. XXI (August, 1933), No. 2, pp. 137-153.

depending upon the pH range of the fixing bath in use. This method will be discussed in detail in Appendix D, to be published in Part IV.

In 1935, Weyerts and Hickman[18] introduced the Argentometer—an instrument for measuring the concentration of silver (in grams per liter) in fixing baths. These authors recommended a safe upper limit of 4 grams per liter, and an ideal concentration of 1.5 grams per liter in the case of circulating baths used in motion picture negative processing.

Over a period of seventeen years, the safe upper limit of silver in negative fixing baths has been reduced from 7.5 grams to 1.5 grams per liter for single bath processing (commercial production), and to 6.0 grams for the first bath and 0.5 grams for the second bath in two-bath processing. For archival use the limits have been further reduced[16], for it has been found that the concentration of silver in the fixing bath affects the permanency of the image.

The author uses a Lumetron Colorimeter (Model P-AC)* to measure the silver content of rinse baths and fixing baths. This instrument must be calibrated in terms of the constituent being determined (silver) and a calibration curve constructed. It would be simpler to use an Argentometer, as it is already calibrated. The colorimeter, however, can be used to determine the concentration of other constituents of photographic processing bath—see Evans and Hanson[19]. One of these authors[20] also describes an "Opacimeter" for use in analysis which is similar to both the Argentometer and the Lumetron colorimeter. For other types of colorimeters which may be used see Gibb[21].

The author has used a titration method** to determine the concentration of silver in fixing baths, employing potassium thiocyanate (KCNS) standardized with silver nitrate ($AgNO_3$), with iron sulfate—$Fe_2(SO_4)_3$—to indicate the end point. Titrations are more accurate, when properly performed, than colorimetric methods, but the former are time-consuming, requiring about one hour, against 15 minutes for the latter, when performed as single operations. Detailed directions for both methods will be found in Appendix E, to be published in Part IV.

[18]Weyerts, W. J., and K. C. D. Hickman: "The Argentometer—An Apparatus for Testing for Silver in a Fixing Bath." Journal of the Society of Motion Picture Engineers. Vol. XXV (October, 1935), No. 4, pp. 335-340.

*Manufactured by the Photovolt Corp., 95 Madison Avenue, New York, N. Y.

[19]Evans, R. M., and W. T. Hanson, Jr.: "Chemical Analysis of an MQ Developer." Journal of the Society of Motion Picture Engineers. Vol. XXXII (March, 1939), pp. 307-320.

[20]Evans, R. M., and G. P. Silberstein: "An Opacimeter Used in Chemical Analysis." Journal of the Society of Motion Picture Engineers. Vol. XXXII (March, 1939), pp. 321-324.

[21]Gibb, T. R. P., Jr.: "Optical Methods of Chemical Analysis." 1st. ed. McGraw-Hill Book Company. New York. 1942.

**Devised by Dr. Edward K. Harvill, Boyce Thompson Institute for Plant Research, Inc.

Tables have been published which show the useful life of fixing baths in terms of the number of negatives of a given size which may be processed in a given quantity of bath before the bath should be discarded. Such tables may be quite unreliable, as is shown in Fig. 10. The curves represent three different batches of fixing bath. The data from which the curves were plotted were taken from tests made during actual production runs. If the criteria of the useful life of a fixing bath are the silver content and the pH, the curves show little correlation between either of these two factors and the number of 5 by 7 inch negatives processed in the bath.

A flowing-water rinse of 1 minute duration was given the negatives between the developing bath and the fixing bath. Even without

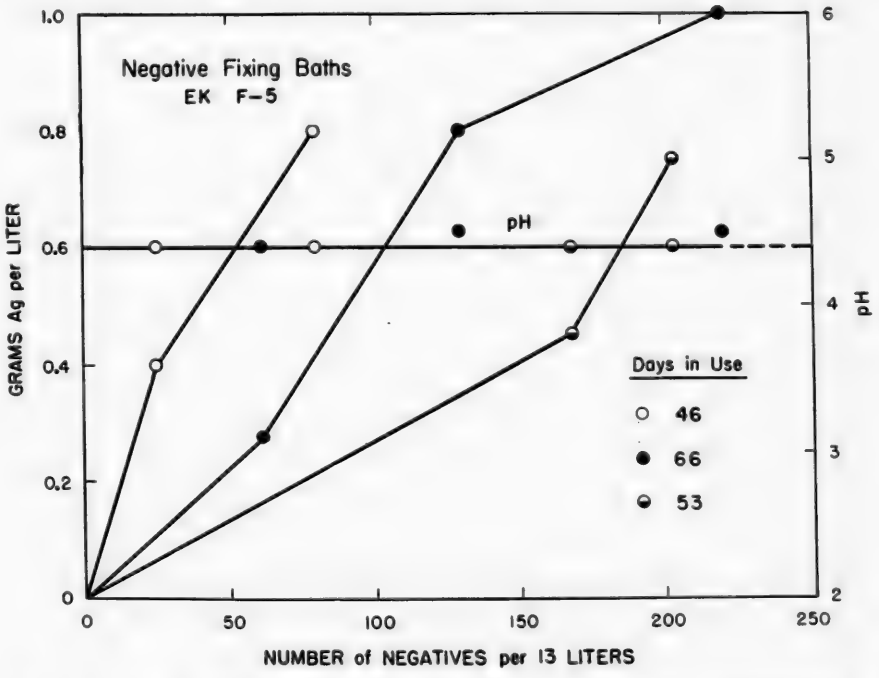

Fig. 10. Curves showing lack of correlation between the silver concentration of negative fixing baths and the number of negatives (5 x 7") processed in each batch of 13 liters.

the use of an acid rinse bath, the pH of the 66-day bath did not go above 4.5, showing that the hardening properties of the bath were maintained during the total period of exhaustion—the bath being

discarded because of its silver content. The 46- and 53-day baths were discarded at a lower silver content because it was convenient to do so, as the tanks needed cleaning at that time. For all three baths, the time to clear for Eastman Panatomic-X sheet film did not exceed 7 minutes. The time of fixation in all cases was 20 minutes.

The lack of correlation between the silver content and the number of negatives processed in the bath may be partly explained by a consideration of one of the functions of a fixing bath—to remove the unexposed, undeveloped silver from the emulsion. The amount of silver removed from the emulsion will, for a given emulsion and developing bath, depend upon the nature of the subject photographed and the extent of exposure and development. In the case of the set-up shown in Fig. 7 (page 116, Part I), 85 per cent of the negative area, occupied by the black background, received little exposure—the negative density for this area being 0.16. As the negative density in the lightest leaves of the plants is 0.95, the fixing bath removed a much greater amount of silver from the background area than from the area occupied by the plants. If a brilliantly-lighted white background had been used, the amount of silver removed from the background area would have been much less. If all subjects photographed were represented in the negatives by a constant ratio—expressed as the ratio of the area of the shadow portions multiplied by the average shadow densities to the area of the highlight portions multiplied by the average highlight densities—some correlation might be expected between the silver content of the fixing bath and the number of negatives of a given size processed in it. This, however, is seldom the case in practice, with the exception of some motion picture processing. Variation in the above ratio from day to day, and from batch to batch, probably accounts for the variation in the slope of the different parts of the curves in Fig. 10.

The pH of a fresh EK F-5 fixing bath, as compounded in this laboratory, is 4.4 (measured with a Hellige hydrogen-ion comparator). The negatives processed in the fixing baths shown in Fig. 10 were developed in the Glycin developer, described in Part II (page 158), and handled in batches not exceeding 12 negatives each. They were drained for a moment after development, and thoroughly drained after rinsing for 1 minute in running water. Even with this procedure there may be some carry-over of developing bath to the fixing bath, but the pH curve in Fig. 10 shows little variation in the pH of the three different baths. Measurements of the pH should be made, however,

as any great increase in pH would indicate a condition in the bath which would affect the hardening properties.

The author recommends that the fixing bath be measured for both pH and silver content at frequent intervals, depending upon the quantity of emulsion processed in the bath. Records should be kept of the date of installation of the bath; date of test; pH; silver content in grams per liter; total number of negatives of a given size processed in the bath at the time of each test; date on which the bath is discarded. Such information is extremely valuable in photographic processing control, as the condition of the bath will affect the quality of the product.

b. Positive fixing baths. What has been said of negative fixing baths applies as well to positive baths, except that the tolerance of the positive bath to silver is much less. The most recent specifications[16] for the safe upper limit for commercial productions are 0.3 grams per liter for single bath processing, and 2.0 grams for the first bath and 0.3 grams per liter for the second bath in two-bath processing.

Fig 11 shows a similar lack of correlation between the silver content and the number of 5 by 7 inch prints processed in the baths. As in the case of negatives, the batches of prints processed each day are usually not equal in number.

The prints were developed in EK D-72, rinsed for a moment in flowing water, and placed in the acetic acid rinse bath (EK SB-1) until about 20 or 30 prints (single weight) had accumulated in the tank. The prints were then well drained and placed in the fixing bath for 20 minutes, washed and dried. All tanks, with the exception of the developing tray and the water-rinse tray, were part of a Pako rocker system equipped with stainless steel tanks.

The pH curve in Fig. 11 shows little variation. Any carry-over of alkaline developing products was neutralized in the rinse bath. The amount of carry-over from the rinse bath to the fixing bath will depend upon the number of prints handled at one time; size of prints; weight of paper stock; extent of draining between rinse bath and fixing bath. Conditions might be such as to produce an appreciable carry-over of acetic acid, and this would decrease the sulfurization life of the fixing bath. Crabtree and Harrt[22] suggest that the acid content of a fixing bath be reduced when used in connection with an acid rinse bath, but do not give specific recommendations as to the amount of reduction which should be made for any given rinse bath formula. The author

has computed that it would require a carry-over of 4.6 liters of fresh acid rinse bath (EK SB-1) to the F-5 fixing bath to equal one-half of the acetic acid (100 per cent CH_3COOH) content of 12.6 liters of fixing bath, and 0.9 liters to equal one-tenth the content. Such amounts might produce sulfurization of the fixing bath, but the above calculations assumes the carry-over of fresh, undiluted rinse bath, which

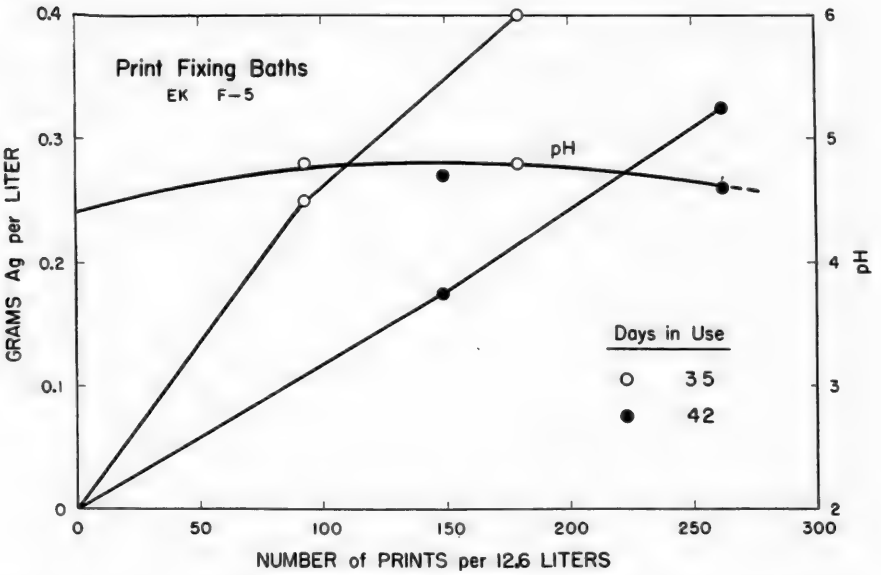

Fig. 11. Curves showing the lack of correlation between the silver concentration of print fixing baths and the number of single weight prints (5 x 7") processed in each batch of 12.6 liters.

is never the case in practice. The rinse bath is diluted by the water-rinse carry-over (in this laboratory) and by developing bath carry-over. Sulfurization of the fixing bath due to carry-over of an excess of acetic acid from the rinse bath has never been experienced in this laboratory.

Records should be kept of the condition of the print fixing bath, as recommended for the negative fixing bath. The recommended specifications[16] for the safe upper limits of the silver content of both negative and positive fixing baths will be discussed in greater detail in Appendix E, to be published in Part IV.

[22]Crabtree, J. I., and H. A. Harrt: "Some Properties of Fixing Baths." Transactions of the Society of Motion Picture Engineers. Vol. XIII (May, 1929), No. 38, pp. 364-405.

F. WASHING

Chemical control is usually not a factor in the washing of photographic materials. Chemicals, however, are sometimes used to expedite the process, and chemical tests can be used to measure the completeness of washing. Crabtree, Eaton, and Muehler[23] give complete directions for the elimination of hypo from negative and positive photographic materials.

The same authors[16] discuss the effect of the pH of the wash water on the removal of hypo and agree with the results of experiments made by Sheppard and Houck[24]. Control of the pH of the wash water in the usual biological photographic laboratory would be difficult, but the biological photographer should be acquainted with its effect.

The design of the washing tanks plays a great part in the efficiency of washing, but each laboratory must work out a washing method depending upon the rate of flow and rate of change of the water in the tanks.

(to be continued)

[23]Crabtree, J. I., G. T. Eaton, and L. E. Muehler: "The Elimination of Hypo from Photographic Images." Journal of the Society of Motion Picture Engineers. Vol. XXXV (November, 1940), pp. 484-506. Also in American Photography. Vol. XXXV (April, 1941), No. 4, pp. 272-286.

[24]Sheppard, S. E., and R. C. Houck: "The Influence of pH on Washing Films after Processing." Journal of the Society of Motion Picture Engineers. Vol. XXXI (July, 1938), No. 1, pp. 67-74.

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Clinical Photographs in Kodachrome

by William F. Payne*

THERE is no doubt a continuously increasing call for photography of clinical subjects in color. E. J. Wall, in his book, "Practical Color Photography", describes many processes which are practical. It is suggested that those interested in color photography read this book. This paper however will deal with one process namely, Kodachrome. There has been numerous articles written on this subject but my contribution to the vast material now available to the biological photographer will consist of a method in use in our laboratories. We have found that it is very practical and it does eliminate the so-called worry as to how Kodachromes will look when they have been returned from processing.

As you already know there are many types and sizes of Kodachrome films. In the bantam size (828) we have K828A for artificial light and K828 for daylight. In the professional type of films we likewise have two emulsions. Daylight to be used as the name implies and Type B to be used with artificial light and only an artificial light that has a color temperature of 3200° kelvin. Far too many of us violate this rule of correct type of lighting and we are prone to blame our poor results on what we call, false claims of the manufacturer. To eliminate this question of light and color temperatures, which will change with the life of the bulb, we will eliminate two of the above films as well as the artificial light that you like and I like, and use one source of illumination, one that is more constant and one that we all can obtain, any time—the flash bulb. Immediately one will think that the cost of the flash bulb again increases the cost of each Kodachrome picture and as one of my friends said, "Kodachrome costs enough as it is and now you add the cost of a flash bulb". Perhaps this is true but the additional costs of the flash bulbs will more than repay you with the results that you will obtain. The results that you will get with the flash bulb exposures will be most constant in densities and color rendition than if you depend on a meter for judging your exposures. Sunlight varies too much, clouds are always in the way, and it is difficult

* From the State Institute for the Study of Malignant Diseases, Buffalo, New York. Burton T. Simpson, M.D., Director. Received for publication April 5, 1943.

to know just how much life your incandescent light has with 3200° kelvin. Of course a color temperature meter will show you that, but it does take time to check with the meter, especially if there are others in the department that use the same meter. The correcting color on the outside of the meter is put there to compensate for the difference in eye sight for each one that uses the meter, and if this is not taken into consideration trouble is bound to turn up. This constant checking, especially if the incandescent bulbs are not new, only delays the surgeon and he is not interested in why incandescent bulbs have to be checked with a meter. All that he is interested in is the results. Many of us check our lights before we enter the operating room but still the meter will not indicate how much life at 3200° kelvin you have in each light. Again few of us can tell just how much of our time and lights the surgeon will require. It is strongly advised to have a large watch glass over your reflector when working with flash bulbs during a surgical procedure. This is a double precaution in case the flash bulb explodes. In my experience during the past two years, (with the improvement in flash bulbs), I have never had a flash bulb explode. However there have been cases reported in which flash bulbs have caused many anxious moments. With this additional precaution taken, flying glass will not occur, for it is not a pleasant thought to even imagine where flying glass will land after it has shattered. The patient or the surgeon will most likely be the target. I know of no more unpleasant situation.

If the color photographs cost too much, then don't take them. Unless the desired results are obtained, you as a biological photographer do not reflect credit on the profession. Our profession has sometimes been guilty of poor work, and when we do not turn out work that is better we are sometimes classified as amateurs. Another important reason for the flash bulb is the fact that we can use smaller diaphragm stops than when incandescent lamps are used. We are all aware of the advantages of the smaller stops. The intense heat of the higher wattage bulbs makes them impracticable when using small stops and also cause squinting and motion of the patient. With the flash bulbs, all of the above mentioned difficulties are eliminated. When making color pictures in the operating room the higher wattage lights do cause considerable heat. Many surgeons object to them. An amusing incident occurred in the scrub room of one of the large hospitals in Buffalo. In this hospital as well as many more, there is an acute shortage of nurses, and in this case a complete hospital unit had left for military service, draining a considerable number of the medical and

nursing staff. One of the attending surgeons was enquiring about the success of the photographer's efforts at a recent operation in which an unusual case was operated on. The surgeon's reply was that the pictures were splendid but he was waiting for the photographer's bill, and if the cost was too high he intended to send the photographer a bill for the services of the additional nurse in surgery which was necessary to "Mop his brow, because of those——lights the photographer used".

We use both the bantam size (828) and professional film. The cameras used with both types of films are the Recomar No. 33 and the Eastman clinical camera. The Recomar No. 33 is 3¼" x 4¼" with 135 mm. focal length f4.5 anastigmat lense. The Recomar camera is also equipped with a bantam back. This bantam back is perhaps one of the most useful accessories that one could have in a laboratory. It also can be used with the photomicrographic camera and anyone with a little ability as a handyman can readily make an adapter so that the bantam back can be fitted to any type of camera. One of its principal features is that ground glass focusing can be obtained and you do see what size field you cover. The resulting Kodachromes are sharp, with the subject in the center of the film. The 3¼" x 4¼" size is as close as one can get to the standard lantern slide size and between this size and the bantam size film, one can do almost anything in color. The Eastman 5 x 7 clinical camera is also used when we wish to make exposures on a larger film. This camera is equipped with a 203 mm. focal length f7.7 anastigmat lens. Most of us use Kodachrome film in a projector and that is another reason why the Recomar camera with the bantam back will prove a very valuable accessory to any biological photographic laboratory.

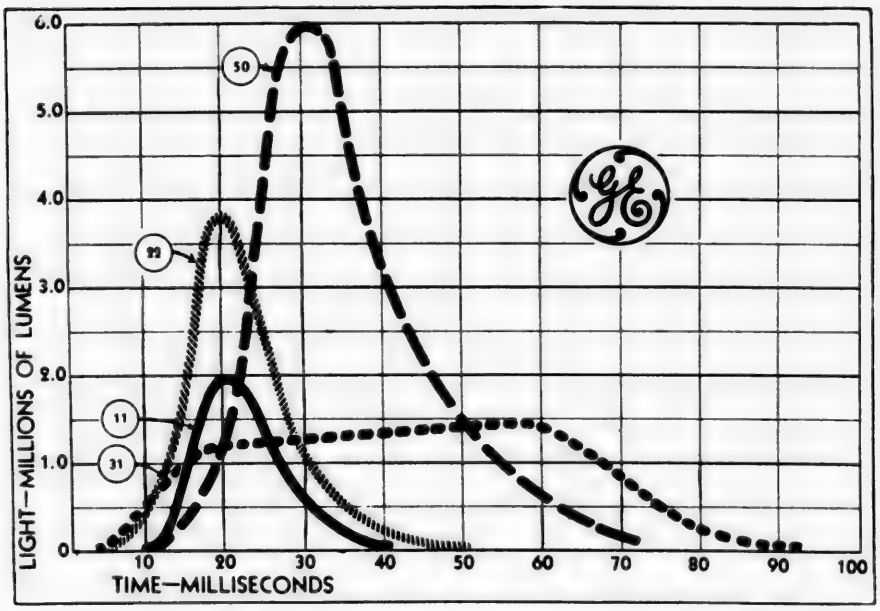
So far I have not told you a thing you do not already know. We will first eliminate two of the above mentioned films and the remainder of this paper will be devoted to K828A film in the bantam size and professional film type B. We will use flash bulbs (GE) No. 11a for the K828A film with no filter and flash bulb (GE) No. 21 for the professional film, using Wratten 2A filter. The purpose of this is readily seen. The reason for the two types of flash bulbs is that one film is faster than the other. The No. 21 flash bulb will compensate for the difference in speed of the professional type of film as compared to the speed of the K828A film.

The most important question left is what stop will I use now that flash bulbs have been decided for my source of illumination. It will be necessary to add additional stops to the diaphragm of your shutter.

This is necessary, as you will find that the difference between one stop to the next stop will be sufficient to throw your exposure off balance and one half of a stop will improve or make your results objectionable. For this reason I would suggest that you mark off a spot, half way between each stop and take a small punch and tap it gently with a hammer. This will leave a small indentation. Next take a small brush No. 0 that has a sharp point and dip it in white paint. Gently drop a small drop of white paint in each additional stop. When you see later on in this paper such an expression as f16.5 it will mean the stop used was half way between f.16 and f22. Next remove the synchronizer from your camera. If you must use it for other work, refrain from using it when you are making clinical pictures in Kodachrome. As we all know, the inverse square law controls intensities of light, be that light visible or invisible. For example, if a camera is six feet from the subject you are required to stop your camera diaphragm down to about f5.6 by taking the flash bulb out of the synchronizer and putting it in a hand reflector. By flashing the flash bulb closer to the subject, you are able to get a more intense lighting and gain from 1 to 3 full stops on the diaphragm. This of course will depend on how much closer the flash bulb is. Again I mention the advantage of smaller stops and its effect on the finished picture. With the synchronizer I personally do not feel the need of 1/100 of a second exposure, when most of the flash bulbs manufactured today are fast without the synchronizer. A glance at the graph in figure 1 shows some of the light that we lose, and which never reaches our photographic film because 1/100 of a second is too fast to allow all the light made by the flash bulb to effect the photographic emulsion. In figure 1 you will find curves produced by four different types of flash bulbs with medium bases. It gives a very good comparison in study of just what each flash bulb will produce. On the other hand if we set our shutter at bulb, open the shutter, flash our flash bulb, then close the shutter you will find that all the light that the flash bulb produces, from the time it begins to light until the light expires, will reach the photographic emulsion you are using and not just a small part of the wave produced by the flash bulb.

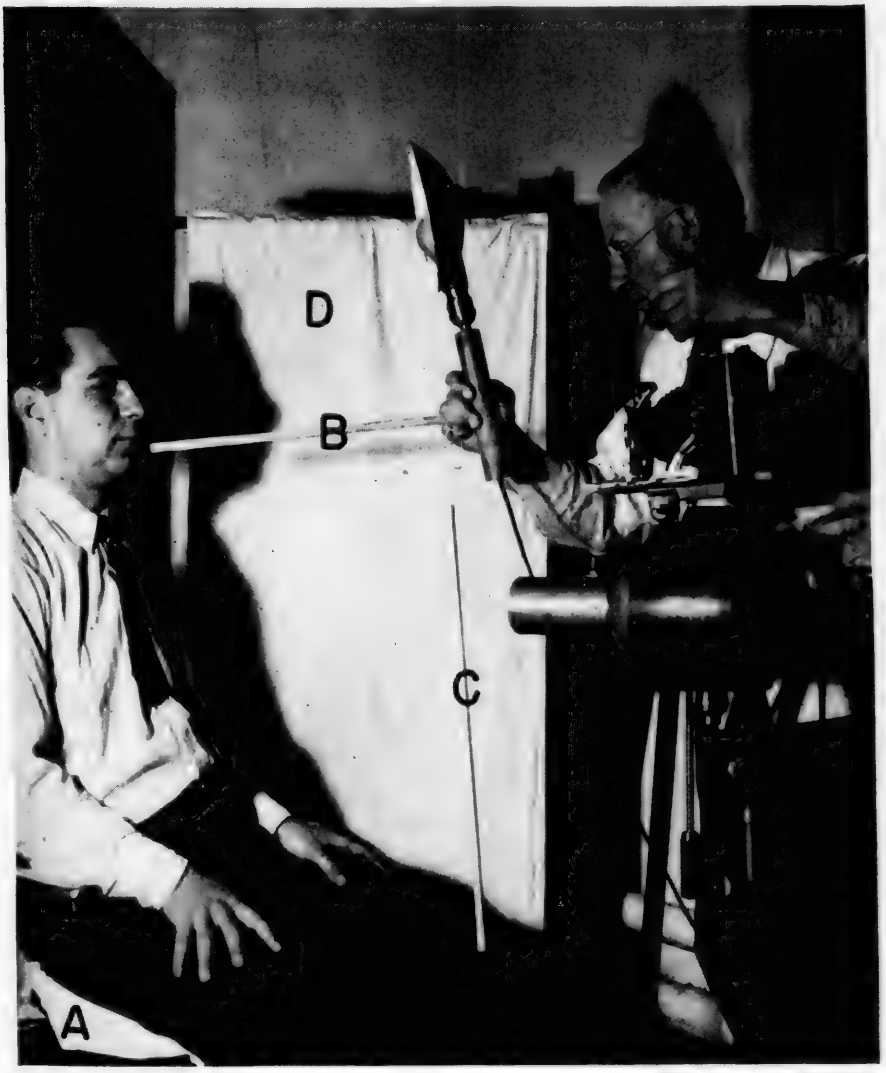
If the distance from subject to flash bulb is accurately measured each time, and the flash bulb is used at this distance each time, then we are bound to get constant results. I know that there are those amongst us who will argue the fact that there is a difference between each flash bulb made by the same manufacturer. They will also argue there will be a difference between the densities of two films made by

the same manufacturer. Perhaps that may be due to the fact that the life of the chemicals may differ at the time that each film is processed. For those that feel there is a difference in each flash bulb, I feel sure that the film has sufficient latitude to compensate for the difference; and for those that bring up the point of processing, my answer is that



I am sure that those who do the processing know their business and the results that most users get proves this point.

In making the measurement of the distance from flash bulb to patient I have substituted a rod made of ⅜″ dowl instead of a ruler. The rod has a loop of string attached to one end and this is looped over the little finger. As soon as the distance has been measured the rod is dropped and the string will prevent the rod from falling on the floor. In the meantime the hand that holds the flash reflector has not moved or changed the distance from the flash bulb to the patient. I have found that if one is to use the ruler to measure, as you turn to lay the ruler down and then turn back to your picture you seldom if ever return to the same point, and here is the secret of success. We have tried a number of times to measure with the ruler, and only once in about twenty times did we have the flash reflector the accurate distance from the subject. The rods seem to correct this difficulty and I do feel the rods are better than a ruler. It may be of interest to the reader that



our distance varied from one-half inch to nine inches when using the ruler and turning around, which obviously will make a lot of difference in your exposures.

Figure 2 shows the general set-up for taking pictures of patients. A is a nose-and-throat chair with a head rest attached. This is of great assistance as it will control movement of the patient's head and will also assist in keeping the rest of the body quiet as well. The photog-

rapher is measuring (B) the distance from the patient to the flash bulb. As soon as this is determined the rod is dropped as explained before. C shows the rod in the position it will stay as soon as it is dropped. D are two home reflectors used to reflect light from the flash bulb so that the sides of the face and the ears will not appear dark on the finished picture. If you are using one flash bulb and there does not seem to be any reason for more than one, some type of reflector must be used. The reflectors in figure 2 (D) are made of white cloth two yards long and twenty-four inches wide, with a metal rod at the bottom to allow them to hang straight without wrinkling. This is also important as a wrinkled surface will not reflect as much light as a smooth one.

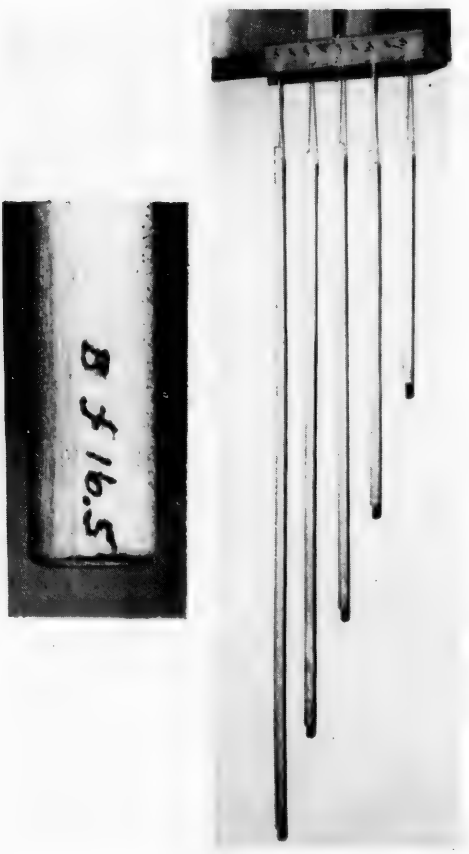


Figure 3 shows the five rods that we use. One is 12″ long, the second 18″, the third 24″, the fourth 30″ and the fifth 36″. On the tip of each rod in figure 3, is a figure which tells what stop is correct when using that particular length of rod. For example in the insert of figure 3, is an enlarged photograph of the 24″ rod and this rod when used requires a stop of f16.5. The stops that we have found to be satisfactory for the Kodachromes we like may not be to your satisfaction, so we suggest that those who are interested in this paper make a few test exposures. For those who may be interested in our findings, a list of the rods and their stops are as follows:

12″ rod f.22.5
18″ rod f 16.5
24″ rod f 16
30″ rod f 11.5
36″ rod f 11.

There are a number of photographers employed in institutions who are requested to make pictures in wards and other rooms besides the photographic laboratory. There are also others who work as free lance photographers with as much medical photography as they can get. In both cases, the five rods explained above will be found very valuable.

A few years ago an epidemic of smallpox broke out in two different parts of New York State; one in the central part and the other in the southwestern part. Photographs of these cases were invaluable, so photographers from the health department were sent immediately to the scene. Of course the photographers were vaccinated before they entered the area of the epidemic. In some homes in the rural districts where the entire family had the disease it was desirable to get pictures of each member of the family. There were other families in which the adult members were the only ones who had the disease, and the children were free from small pox due to the vaccination they received by the school physician. In a number of these homes oil lamps were the only source of illumination and in every case the photographers were unable to get a single picture. This is no doubt an exceptional case, but men who work for any state health department generally do get the exceptional cases. Not so long ago the author was requested to photograph the results of severe burns caused by an explosion. Some pictures were required to be taken at the scene of the catastrophe, while others were taken in a field at least 300 yards from the nearest electric wire. With the aid of a hand flashlight for focusing the camera, this picture was accomplished with a flash bulb. In this type of work it is advisable to carry a portable background. One that has been found very practical is an elaborate window shade. On one side of the shade the color is black which is used in photographing subjects that are light in color. The reverse side of the shade is white, which can be used to photograph subjects dark in color. When transporting this background it can be rolled up and put in a bag. It is advisable to roll it up so that the white side is on the inside as white soils very easily. The shade is 36″ wide and 7′ long. It is suspended from an iron rod, with a crow foot base, by a piece of heavy cord with a loop at each end which is passed over the pin that protrudes from both ends of the shade roller. This portable background, when collapsed, occupies a space about 38″ long and about 4″ in diameter. This also includes the stand that supports it.

SUMMARY

It has been our experience that Kodachrome pictures are more consistent in densities by using flash bulbs as a source of illumination.

Measuring rods have proven a valuable guide in making exposures. They are inexpensive, easy to obtain and not cumbersome to transport.

The secret of success is the constant distance these rods afford in making exposures, and the question of diaphragm stops is eliminated.

The use of small diaphragm stops is possible due to the intense light without constant heat. This also gives a much greater depth of focus to the resulting photographs.

Flash bulbs can be used even if electric current is not available, as the hand reflector will operate with small batteries.

Lieut. Eddy wrote the Secretary from the field, June 17th, 1943. The first page was taken up with B.P.A. affairs, which apparently continue to interest him even at so great a distance. Only on page 2 did he mention his own work, as follows:

"It probably would make little difference to the enemy if I would give the whole story, but censorship regulations being what they are, we must abide by them. I might say, however, that we are becoming acquainted with some very unpleasant facts about photography in the tropics. What little work we are able to produce is done with fine equipment from the States, sensitive material which succumbs to the ravages of heat and humidity quite rapidly, lukewarm dirty water, dust laden atmosphere, and no darkroom. . . . Another curious thing we observed the other day was our inability to ferrotype glossy paper. It seems to make no difference what kind of paper we have, it just won't get shiny. And we could go on and on and still not hit bottom in this seemingly inexhaustible presentation of problems. Now that we are becoming used to it, it doesn't seem quite as tough as it did at first.

"Please keep the news of the Association coming this way whenever you find an opportunity to write."

Lieut. Eddy's address is 20th General Hospital, APO 689, c/o Postmaster, New York, N. Y.

How to Prevent Denlinphobia

by Edward V. Taylor*

DURING a recent tour of a psychopathic ward the guide stopped before a barred door and said impressively, "Here is a true case of Denlinphobia." We stopped, peered in at the pathetic figure crouched in one corner of the room, a cracked dental mirror in one hand, a shattered cut film holder in the other. Around him the floor was littered with splinters of other film holders, mute evidence of his recent activities. "Yes," continued the guide, "his only desire in life now seems to lie in breaking film holders—tearing them bodily apart."

While many of the causes of Denlinphobia are still little known, this much can be said. The disease is a mental derangement caused by the subject's brooding overly much on the pernicious crimes of the Denlins. And in case you didn't known it, the Denlin, first cousin to the Gremlin, specializes in gumming up the works in dental photography.

The best prevention of this disease is a thorough knowledge of typical Denlin procedure, and of some methods useful in circumventing many of his fell designs. And by the way, much of the following information can be readily adapted to other forms of photography—especially photomacrography. So, after a brief description of the equipment used, let us begin with a few case histories.

For those technically minded, these case pictures, none of which is retouched or spotted, were made with an Agfa Universal View 5″x7″ camera equipped with a Goerz Dagor 8¼″ lens. A truly adequate lens shade was imperative, partly because of the many gleaming pieces of dental equipment that can fog a film with little provocation. Tripod was the readily adjustable Agfa Universal tripod, equipped with a Folmer-Graflex tilt top. Exposures determined by Weston meter tempered with a good bit of judgment resulting from test exposures and "trial and error." Lighting was generally by two No. 4 photofloods in "soup bowl" reflectors. An excellent suggestion by a dentist friend of mine resulted in using a white enameled stick about 20″ long to measure the distance from the lens to the mouth of the patient, thus insuring fairly

* General Electric Company, Cleveland, Ohio. Received for publication April 29, 1943.

equivalent image sizes on negatives of succeeding cases. Naturally, the measuring stick works best on a rear-focusing type of camera, because of the necessarily long bellows extensions often employed. The choice of film depends a good bit on the results desired. In our type of work it is advisable to obtain a certain degree of color separation between the tooth and the gum at the gingival. Therefore, after experimentation, we adopted Super Plenachrome—this rendition suiting our purpose better than a Panchromatic.

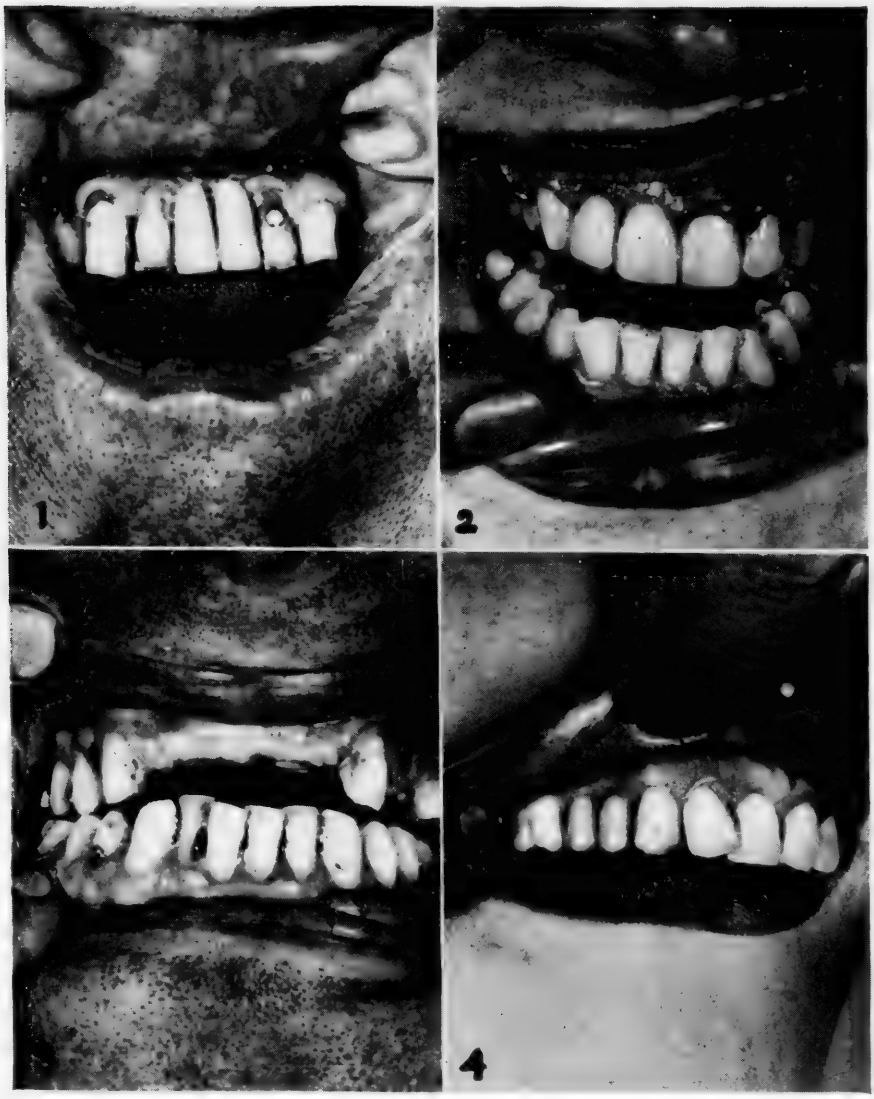
One other piece of advice—regard your subject with a detached attitude . . . just so many teeth and a certain amount of gum area to be photographed. Otherwise you may run up against a case that will say to you—after they've undergone considerable dental work—"For Pete's sake, stop grinning at me." Once upon a time this remark disconcerted me considerably.

Now, some of you may doubt certain of the Denlin facts presented in these case histories. To those, I can only recall Lord Thomas Dewar's statement, "Minds are like parachutes. They only function when they are open."

Case 1: This picture, while satisfactory to our purposes, received certain misanthropic ministrations of a clever Denlin. As you can appreciate, working at such close proximity to the subject, the camera's depth of focus is considerably reduced, even with stopping down. This Denlin stealthily polished the visible metal on the restoration, with the result that focusing was done on the highlights instead of the bridgework itself. You will note in this respect that the focus is far better on the tongue itself. To overcome this focus on the teeth themselves, preferably on the biting edges or on the gingivals or gum line. In passing, it may be noted that this type of photography is not one for beauty—it is designed to show both perfections and imperfections in oral cavities and the rest of the face can go climb a tree. Hence, if the patient has any whiskers or freckles or moles, said skin qualities will show up, and how.

Case 2: Little comment on this one. We were fortunate in thwarting most of the Denlin's designs.

Case 3: Just before the shutter clicked, a Denlin equipped with bubble pipe deposited a saliva bubble smack between two lower teeth. The best way to avoid this is to dry the gums slightly with cotton gauze. Then, immediately before exposure, a blast of air will blow the



Denlin's topsyturvy. Click the shutter before the Denlins have time to counter-attack.

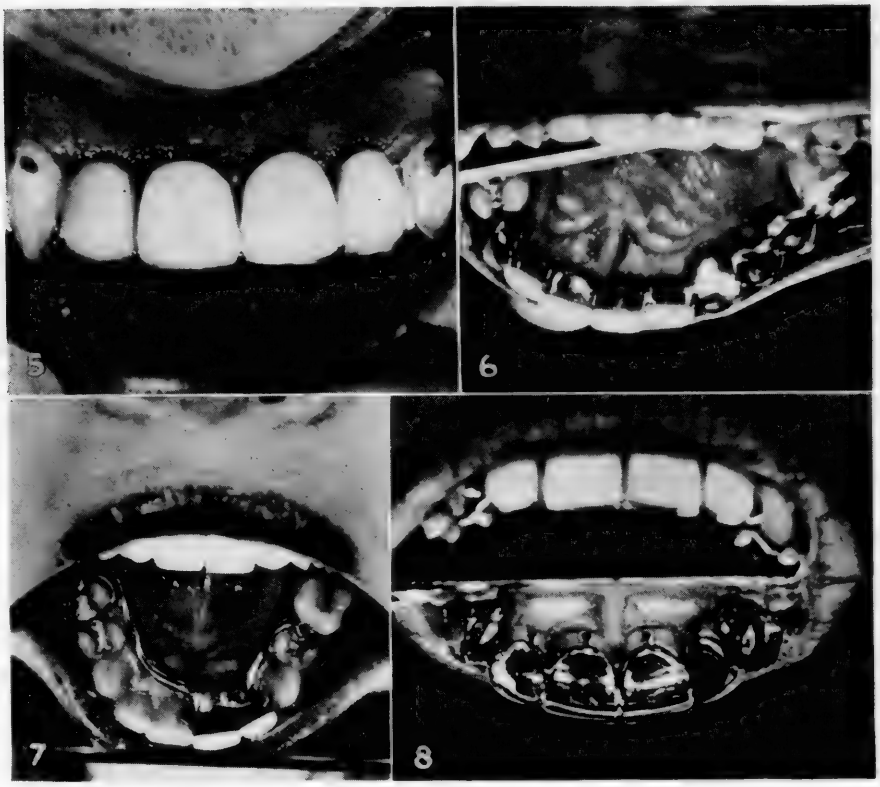
Case 4: A Denlin tickled the patient with a feather, causing her head to shift ever so slightly. The result was that highlights were caught directly on the gingival, or gum line—precisely what we wanted to avoid. There is only one prevention of this, arrange your

lighting high or low enough so that if the patient does move her head the highlights will not be picked up in critical areas. This requires a goodly amount of experience.

Case 5: The problem here was to light a subject so as to show a lack of adaptation between the teeth and the gum at the gingival, also the little bubble in the gum caused by pressure of the restoration against the gum. After a bit of experimenting, you will find a low position for your lights where the proper oblique light will bring out the desired results. Unfortunately at this point the Denlin will likely whisper in your ear, "This is your only chance to get this shot. Tomorrow will be too late. Dub this and you might as well go back to selling brushes." This is a favorite device of the Denlins, and about the only prevention is to take two shots of the subject. In this way you can sometimes catch the little imp unawares the second time—he having thought all his dirty work accomplished on the first shot. Another psychological trick they use is to so distract your attention by pessimistic and screwball thoughts that you neglect to remember that owing to the close distance you are working and the consequent long extension of your bellows your f values are completely changed. Therefore, in making your two shots, it is often best to make your exposures different.

Now for a few mirror shots. The arrangement of lights for mirror shots, also the focusing, is more difficult than in other types of work. This is caused by the habit the Denlins have of tipping the mirror—just a teensy bit—after you think you're all set for the dental picture of the year. About the only advice we can give is to make sure the patient's head is firmly—and I do mean firmly—rested against the headrest, and to pick with care the man who holds the mirror. It is absolutely useless to attempt to take a mirror shot with someone holding the mirror who's the slightest bit nervous. He will merely unconsciously aid the Denlins in their dirty work. And in the case of magnifying mirrors this is of even greater importance. Of course the old rules of mirror photography apply here. To-wit; your focusing is done to the mirror and back to the reflected surface. As a result, other mouth areas not reflected, such as the lips, will be much more out of focus than at first you might presume.

Case 7: Little comment. One Denlin started to climb toward the mirror with an atomizer; objective, to fog the mirror as per an old established Denlin custom. Fortunately, we saw him in time and slightly pre-heated the mirror. Since the Denlins have a hyper-sensitive skin, the warm mirror kept him away until the shot could be made.



Case 8: Same comments apply that were given for Case 7.

We do not have the space to take up more of the many Denlin tricks in this article. And their portfolio of pranks is nearly inexhaustible—such as pushing a fold of the lip to hide a critical area, or jumping on the foot pedal that lowers the chair, all just as you are making the exposure.

However, one last word—and this is about photographing woman patients. Most women come to the dentists' chair with enough lipstick to render lips almost black. The first request a dental photographer should make in nearly every case is for the lipstick to be wiped off with a bit of cotton gauze.

Oh yes, and speaking of women, never, NEVER show her a case picture of herself. If you do. . . .

IT WASN'T A DENLIN THAT SNATCHED YOU BALD.

Association News

A FURTHER NOTE ON OBTAINING PHOTOGRAPHIC SUPPLIES

In a letter addressed to the B.P.A. on June 10th, Mr. H. C. Hopper, Chief of Section VI, Consumers Durable Goods Division of the War Production Board, assures us that essential film in our field "will be given utmost consideration in the establishment of policies governing the distribution of materials which can be made available in civilian markets."

He adds: "Of course, the requirements for films and papers by the Armed Forces remain exceedingly high and so we should like to urge that all means of conservation be employed by members of your group."

To obtain film for essential medical and educational purposes a PD-1A form must be filled out and sent to the nearest regional WPB office. You are requested to order only a thirty-day supply at one time. An AA-5 rating will be given to essential orders which amount to less than $100. Larger orders will be sent by your local Board to Washington. Once your order has been rated AA-5, the dealer with whom you place it can send to the manufacturer for your film, instead of supplying them from his own reduced stocks.

These transactions may take time. But if the film is available at all from the manufacturer it must be supplied on an AA-5 order. Therefore, if you cannot obtain film for medical and educational purposes which you feel to be essential, the trouble may be that your local WPB does not agree with your interpretation of "essential". Or, either the purchasing agent who orders for your institution, or the WPB member he contacts may not be fully instructed on Washington's policies in regard to film for medical and educational purposes. The orders issuing from the central Board are necessarily so detailed and complex that it is easy to make a mistake on one item. Your best course would be to have an interview with your purchasing agent if you have one; if not, to go directly to the local WPB and talk the matter over with one of its members. If a mistake has been made in that office in regard to Washington policies, it can quickly be cleared up. If, as is more likely, your order has not received the AA-5 rating because your purposes were not considered essential, you may be able to amplify the statements made on your application. Or you may come away satisfied that your own project *is* unessential compared to others for which film must be supplied first. If an impasse results, with all sides still unconvinced, get in touch with us, or write the Photographic Section, Consumers Durable Good Branch, War Production Board, Washington, D. C., stating the facts as clearly as possible.

SUSTAINING MEMBERS

Some individuals with an interest in scientific photography help support a wider range of activities in the Association by taking out Sustaining Memberships of $10.00. The privileges of Sustaining Members and regular Active Members are the same. Either type of membership may be chosen each July when the dues become payable.

A Sustaining Member pays slightly more in dues than three regular members. But because only one Journal Subscription need be furnished him by the Association, he contributes as much to the Association's available funds as eight regular members. It is apparent that he is a very real addition to the Association financially. More than that, his gesture of interest and cooperation in taking out this type of membership is cheering to the Association as a whole. We take pleasure in thanking the following Sustaining Members for their friendly support:

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Univ. Office, Magee Hosp.
Pittsburgh, Pa.

Varden, Lloyd E.
Agfa Ansco Company
Binghampton, N. Y.

NEW MEMBERS

The following members have entered the B.P.A. since the last list of new members was published in the December 1942 Journal, Vol. 11, No. 2. We welcome them into the Association:

Adams, Dr. M. Vaun, 803 Government St., Mobile, Alabama.

Bishop, Carl M., Rt. 1, Durham, N. C.

Boyle, Beatrice A., 19240 Battersea Blvd., Rocky River, Ohio.

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Brown, John S., M.D., F.A.A.P., 101–21st St., Saskatoon, Saskatchewan, Can.

Chavarria, Dr. Pera, San Jose, P.O. Box 688, Costa Rica.

Creskoff, Adolph J., 3400 Spruce St., Philadelphia, Pa.

Dunbar, John C., M.D., 820 Empire Bldg., Pittsburgh, Pa.

Duryee, A. Wilbur, M.D. (*Amy E. Close*[1]), 140 E. 54th St., New York, N. Y.

Gifford, Dr. Harold, 3636 Burt St., Omaha, Neb.

Golden, Private Robert (*Emmet E. Shipman*[1]), 668 Navigation Training Squad, Mather Field, Calif.

Gorelick, Cpr. Joseph, 33rd General Hospital, APO 4583, % Postmaster, New York, N. Y.

Gorham, W. C., Colgate University, Hamilton, N. Y.

Grabherr, Leopoldina (*Frank C. Reed*[1]), Instituto Bacteriologico de Chile, Santiago de Chile.

Grabherr, Luis (*Frank C. Reed*[2]), Servicio Nacional de Salubridad, Santiago de Chile.

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Henry, Alfred E., 785 Capitol Heights, St. Paul, Minn.

Jackson, Robert M. (*Theodore E. Catelli*[1]), 50 W. Front St., Red Bank, N. J.

Kirwan, William E. (*Louis A. Waters*[1]), 128 S. Church St., Schenectady, N. Y.

Knight, Dr. Harry C. (*C. H. Binford*[1]), U.S. Marine Hospital, New Orleans, La.

Lecher, Sylvia M. (*Albert Sadler* [2]), Eloise Hospital, Eloise, Mich.

Loden, B. M., 2600 Woodward Way, Atlanta, Ga.

Magalhaes, Hulda (*J. B. Haulenbeek*[14]), Dept. of Zoology, Duke University, Durham, N. C.

Malick, Jean B., D.D.S., 606 W. 116th St., New York, N. Y.

Nisbet, Douglas S. (*J. B. Haulenbeek*[15]), U.S. Public Health Service, Medical Center for Federal Prisoners, Springfield, Mo.

Platou, Dr. R. V., 1430 Tulane Avenue, New Orleans, La.

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Rhodes, Carol (*Alex Gravesen*[2]), 85-10-34 Ave., Jackson Heights, New York, N. Y.

Riser, Roy D., M.D., 120 Main St., Park Ridge, Ill.

Shaffer, Harry G., M.D., Clearfield, Pa.

Slavik, Edward F., M.D., 408 S. Spring Ave., La Grange, Ill.

Sweets, Dr. Henry H., Jr. (*Robert A. Sage*[2]), Dept. of Pathology, Medical Branch, Galveston, Texas.

Warner, C. (*Louis Schmidt*[22]), % Commonwealth Health Lab., Rockhampton, Queensland, Australia.

Withee, John E. (*Evelyn Jardine*[1]), Lebanon, N. H.

Forestry

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VOLUME XII 1943 NUMBER 2

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EDITOR

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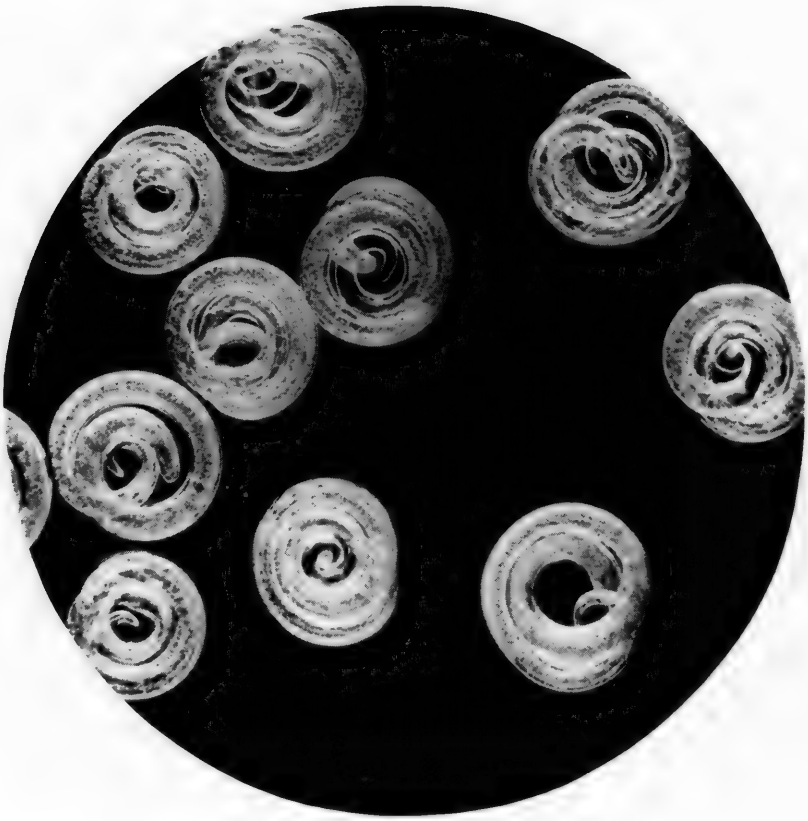

TRICHINELLA SPIRALIS (Experimental)

Female worms under dark field illumination. The worms were mounted in saline, killed with a drop of formalin and cover glass applied. They were photographed immediately since they soon lose their detail after death. DATA: *6v ribbon filament lamp. Achromatic condenser N.A. 1.40, with top element removed and dark field stop placed in the slot beneath the diaphragm, the latter being wide open. 16 mm. apochromatic objective, 10x compensating ocular, 5 x 7 Eastman Commercial Ortho plate, developed in DK 50. Exposure was 4 seconds, no filter. Magnification 100 diameters.*

This copyrighted photomicrograph is reprinted from a monograph titled "Trichinosis", by Dr. S. E. Gould. Chas. C. Thomas, publisher. Photographed by Albert Sadler, Eloise Hospital, Eloise, Michigan.

Experience in Kodachrome Photomicrography

S. I. Kornhauser, Ph. D.*

DURING the past two years the author has made several hundred Kodachrome lantern slides using Eastman K828A films. These are, almost without exception, sharp and excellent as to color. Much time was spent in searching the slides for the best possible fields, and only highly selected slides of the best quality and staining were used. Slides with contrasting colors make the best transparencies. With this in mind the author devised the so-called "Quad" stain, utilizing definitely separated parts of the visual spectrum, violet, green, orange, and deep red. This stain likewise brings out the various tissue elements with great clearness. It is axiomatic that the transparency can be no better than the original slide. Time spent in searching and marking the best fields is well spent. The slides should be selected and the fields marked before one begins to photograph, so that one can concentrate entirely on the picture-taking when he starts. I will first describe my apparatus which has remained practically unchanged since the beginning, and secondly I will describe the use of the apparatus.

I. Illuminant

The Bausch & Lomb Research Microscope Lamp with 108 watt 6 volt ribbon filament bulb is used. A fixed voltage transformer is used, our line current being 120 volt A.C. In the primary circuit, I have inserted a type 22 Bradley-Stat in series and in the secondary circuit going to the bulb, a Triplett, No. 335 volt meter in parallel. This arrangement permits me to vary the voltage to the bulb from less than 5 volts to 6.4 volts and to know exactly at what voltage the exposure is made. In taking the pictures, I generally use an Eastman Color

* Department of Anatomy, University of Louisville, Ky. Received for publication October 1, 1943.

Compensating Filter No. CC6, which is a very light blue. It is 2" x 2" square and mounted between good quality glass. If a bluer shade is desired to get the correct color effects, I use a Wratten filter No. 78B. For visual arrangement of the microscope slide and adjustment of the substage condenser, I drop the voltage to about 5 volts and place a 1.5 neutral tint glass of Bausch & Lomb in front of the blue filter. This protects my eyes from the glare of the filament. The distance of the lamp from the microscope is kept constant. The front edge of the lamp base is 34 cm. from the middle of the microscope mirror. At this distance, if one focuses the filament of the bulb sharply on the under surface of the microscope diaphragm, it makes a band of light wide enough to fill the condenser and gives an adequate cone for an objective, N.A., 1.30. When the lamp is once focused, it need not be changed again. I have cemented a scale reading from 1 to 5 on the lamp just in front of the iris actuating lever. This is useful in recording the size of the aperture used during an exposure.

II. THE MICROSCOPE

I use a Bausch & Lomb CAS microscope. It is an old but sturdy stand with excellent fine adjustment and substage centering screws. It is provided with a Bausch & Lomb Aplanatic substage condenser N.A., 1.40. This condenser is a three lens dissectible combination. For the 16 mm. objective one uses the bottom element only; for the 8 mm., the bottom and middle elements; for the 4 mm. and oil immersion, the complete three lenses. I have cemented a scale below the miscoscope iris actuating lever which reads in half intervals from 0 when closed to 3.5 when fully open. This is essential in recording an exposure so that one may duplicate the conditions subsequently.

I find the recent quadruple nosepiece of Spencer superior to any other I have tried, because its central bearing is sturdy and exact and the centering of the fields of the four objectives placed on it can be accomplished with precision if one uses a cross hair on the stage and in the ocular. My objectives have consisted of Zeiss apochromats 5x, 10x (16mm.), 20x (8mm.), and 40 (4mm.). The 40x has a correcting collar for the cover glass thickness. For oil immersion exposures, I use a Bausch & Lomb 90x (2mm.) apochromat with Mersoil between the top of the condenser and the slide. I have used three Zeiss compensating oculars, 4K (6.2x), 6K (9.4x), and 8K (12.5x). These

allow my magnifications to vary from 20 diameters to 640 without increasing the length of the bellows.

III. The Camera

The Bausch & Lomb K Camera somewhat modified is used. (See Figs. 1 and 2.) The base, vertical rod with camera locating collar and

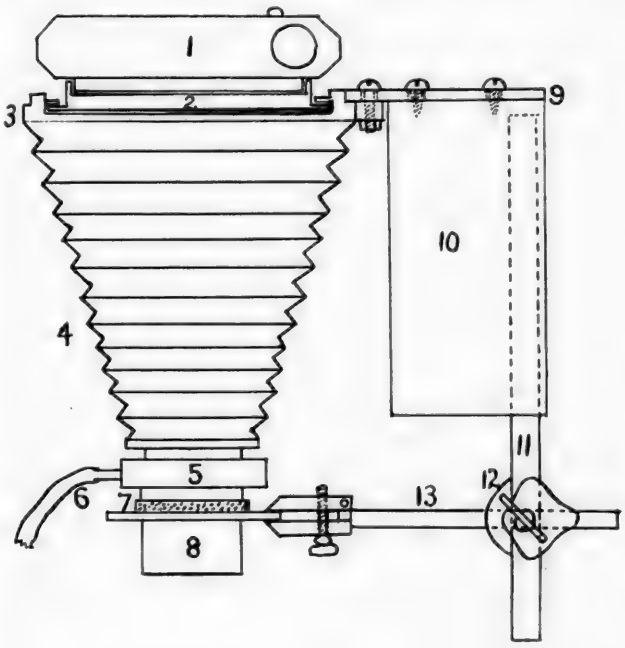

Figure 1.
Right lateral view

1. *Kodachrome adapter*
2. *Base plate of adapter*
3. *Camera back*
4. *Bellows*
5. *Shutter*
6. *Shutter cable*
7. *Sponge rubber ring*
8. *Microscope attachment*
9. *Metal plate*
10. *Maple block*
11. *Adjusting rod for 8*
12. *Two way rod clamp*
13. *Jawed clamp for 8*

dark chamber bracket are used but a different dark chamber taking 9 x 12 cm. cut film holders has been substituted. This is attached to the swinging bracket by means of a wedge-shaped maple block and drilled aluminum plate. The chamber is provided with a relatively cheap shutter. The shutter has, however, three good points. First, it is actuated by a cable; second, its momentum is small; third, it does not require resetting for multiple exposures. The chamber has a variable bellows which is handy when using the long 5x objective. The camera locating collar on the vertical rod has been kept at a fixed distance from the heavy cast iron base, 37 cm. for all exposures. This has made one less variable.

An Eastman Miniature Kodachrome adapter for Kodak Recomar No. 33 is used in place of the cut film holder. Its base is 9 x 12 cm.,

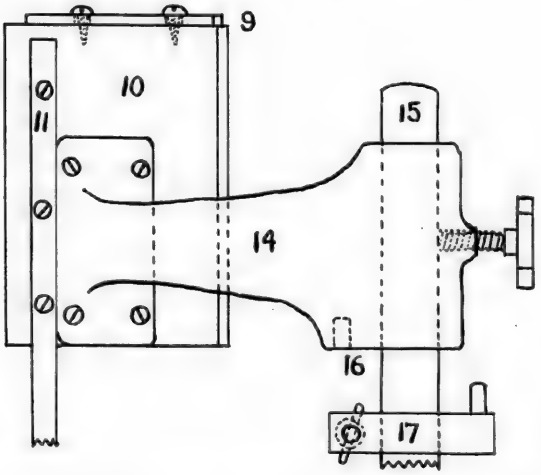

Figure 2.

Rear view

9. Metal plate
10. Maple block
11. Adjusting rod for 8
14. Swinging bracket of B&L K-camera
15. Vertical rod of K-camera
16. Hole for peg on 17
17. Camera locating collar

and it has a centrally placed opening 3.2 x 4.3 cm. The focussing glass is directly above. Its frosted undersurface I have criss-crossed with two fine pencil lines, and in the center, I have cemented with balsam, a 10 x 10 mm. No. 1 cover glass. These features are invaluable in getting an exact focus. For the final focus a ten power triple aplanat magnifier permanently mounted in a bored cork at a height at which the pencil lines on the focussing glass are sharpest is used. The central 10 x 10 mm. cover glass area is used for the final focussing of the details of the cells or tissues.

To connect the dark chamber to the camera, I use the Eastman Kodak Precision Enlarger microscope attachment. This consists of an aluminum tube 35 mm. in diameter, plush lined, attached to a square plate 65 mm. in diameter. This attachment is adjustable as shown in the diagram. It should slip down over the microscope tube freely to prevent any jar of the shutter being transmitted to the microscope. Between the shutter and the square aluminum plate, I have placed a sponge rubber ring 4 mm. in thickness. This is a further precaution against shutter jar.

The Camera rests on a heavy albarene table having stout iron legs. Between the table and the base plate, there are four rubber sponges to prevent vibrations of the building.

IV. The Exposure Meter and Holder

A Weston Master Universal Exposure Meter is used to determine the length of exposure. It is used with the baffle open as intended for dimly lighted scenes. In order that the lens over the cell be exactly placed so that its center will coinside with that of the film, a meter holder was constructed, out of a piece of ⅛″ plywood and the meter fastened to it by two brass brackets as indicated in diagram 3.

There are two circular openings in the board; one for the open baffle, and the other for the meter lens. When the Kodachrome adapter

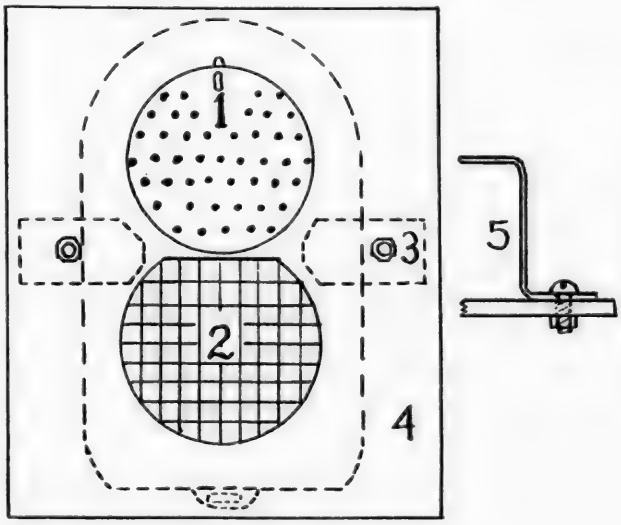

Figure 3.
Under Side of Meter Holder

1. *Opening for baffle*
2. *Opening for meter lens*
3. *Bracket holding meter*
4. *Plywood board*
5. *Lateral elevation of bracket 3.*

is slid out at least 12 cm., the meter board is dropped in its place. The meter then receives the light rays which would have passed through the 32 x 43 mm. opening in the adapter plate.

V. Use of Apparatus

a. Visual Adjustment of the Slide

With the proper filters in place, and the lamp voltage reduced, the camera body swung out, the microscope slide is viewed with the optical combination to be used in the exposure. The selected field is perfectly centered, and the area examined carefully for any foreign substance on the slide or cover glass. The condenser and substage iris are then

adjusted for optimum illumination and definition. Remove the ocular and examine the rear lens of the objective to see that it is evenly illuminated over a circular area, centrally placed, and at least ¾ the diameter of the rear lens. Closing the iris too much will cut down the illuminated area and will result in a reduction of the N.A. and an elimination of details in the object. The focus of the condenser is likewise of greatest importance in filling the rear lens. A polished uranium glass block 1 x 2 x 5 cm. obtained from Bausch & Lomb allows one to visualize the cone of light from the condenser, and to see its breadth and focus. If one closes the lamp iris and focuses the condenser so that the aperture of the iris and the object on the stage both appear clearly in the microscope field, he can be sure that the condenser is at the proper height. The lamp iris is then opened to include the whole field to be photographed.

b. Focussing the Camera

Swing the camera body with Kodachrome adapter in place over the microscope. Remove the neutral tint glass and increase the voltage with the Bradley-Stat to at least six. Focus the microscope and see that the desired area is inside the area of the focussing glass, that it is evenly illuminated and free from color fringes. Examine the whole field and especially the central cover glass portion with the 10x hand lens for all the features desired in the picture. Slide the adapter out far enough to permit the meter board to be inserted having all conditions similar to those at which the exposure is to be made. Read the meter and compute the exposure time as explained below. By using Panatomic X films, we found by trial that a meter reading of 2.4 with 1/100 second exposure on our shutter gave best results. In terms of Kodachrome A, this would be 3.2 on the scale. Therefore, divide the meter reading into 3.2, and the quotient equals the number of 1/100 seconds required for the exposure. If the reading is 0.8, use 4/100 seconds. I make multiple exposures with the shutter set at 1/100, because I have found that, testing with a photometer, the 1/50 and 1/25 second exposures on my shutter were not two and four times as long as the 1/100 but only 18% and 22% longer. This knowledge, however, allows greater flexibility in making calculations for exposure when the meter reading does not divide evenly into 3.2. If, however, one wishes to change the meter reading so as to make it divide evenly into 3.2, he can alter the voltage of the filament slightly or vary the lamp iris somewhat. But one should be sure in doing the latter that one does not cut down

on the evenness of illumination of the field. I strongly advise against the use of the neutral tint filters to cut down on too high a reading as it throws the colors off. Most of my exposures range from 1/100 to 8/100.

c. Taking the Picture

Remove the meter, slide the Kodachrome adapter back into place. Re-examine the image on the ground glass and central cover glass area with the hand lens and make the final focus. Set the shutter at the 1/100 mark, and gently slide the film holder into ready position. Make the calculated exposure without touching the table, microscope, or camera. Slide the film holder back into the same area and roll off the exposed portion. Reduce the voltage on the lamp, and turn it off. Record all the variable factors in a log book as follows:

Film Number	Object and Stain
Exposure Number	Objective & Ocular
Microscope Iris	Meter Reading
Lamp Iris	Exposure Time
Voltage	Result:
Filter	

The constants which should be in the log book are: 1. table of magnification for all optical combinations used. (Ascertained by using a stage micrometer). 2. Height of the top of the bellows from the base plate. 3. Distance of the lamp from the mirror.

While I realize that this article is merely a description of a method developed by me, which attains results I consider worth while, still it does not maintain that it cannot be improved upon. I trust, however, that my experience may help others to attain good results earlier and at less cost.

BOOK REVIEWS

THE AMERICAN ANNUAL OF PHOTOGRAPHY, 1944. Vol. 58. Edited by Frank R. Fraprie, F.R.P.S., and Franklin I. Jordan, F.R.P.S. Published by The American Photographic Publishing Company of Boston, Mass. 240 pages, 77 illustrations, 7¼ x 10 inches. Price: $1.50 paper, $2.25 cloth.

If you wish to consolidate your photographic thinking, read the first article, "A Personal Credo — 1943" by Ansel Adams. It is one of the finest, clear thinking essays that have appeared in any photographic publication. The 12 articles include one on "A New Bromoil Technique" by E. Lind, and one on "Carbro" by Carlton E. Dunn. Of special interest to our B. P. A. members are three Nature Photography articles — "The Making of a Natural History Photographer" by Rutherford Platt, "Flower Photography" by Jack Wright, and "Pattern for Wild Life" by H. H. Sheldon. Included as usual is the "Who's Who" listing, and a practical formulary. Well done, Messrs. Fraprie and Jordan!

Ray Miess.

THE YEAR'S PHOTOGRAPHY, 1943-1944. A Royal Photographic Society Annual Publication.

The Royal Photographic Society of Great Britain held their eighty-eighth Annual Exhibitin in London in September and October, 1943. The number of prints exhibited were so great that it was necessary to divide them, and show half in September, and half in October. Material from this Salon was used in compiling "The Year's Photography, 1943-44." Shown are 52 selected prints, representing a number of photographic fields. The pictures are excellent. United States exhibitors are well represented. Our British co-workers are to be congratulated and commended. We can well imagine the innumerable handicaps that were overcome in order to produce these pictures, organize the Salon, and publish the Annual.

Ray Miess.

Reduction Kodachrome Copies of Kodachrome Originals

by Donald J. Wald*

AT times it becomes necessary for a medical photographer to make a Kodachrome copy of a Kodachrome transparency in a different size from that of the original.

Eastman Kodak Co.[1] at Rochester, New York, maintains such a service. However, they have not published their methods or data concerning such processes.

Stanley McComb[2] published an article in June of 1941 on the copying of Kodachrome transparencies in Kodachrome enlargements.

Insofar as is ascertainable, no method has been published for making 35 mm. reduction Kodachrome transparencies from larger 3¼" x 4" Kodachrome transparency originals.

The work upon which this article is based, was done in May of 1942, which was before Eastman Kodak Co. instituted this service. Eastman's, however, insofar as I can determine, have never published a description of their technique of duplication.

Reduction Kodachrome copies of Kodachrome originals can be done by anyone possessing a miniature camera with a ground glass attachment. The method of copying is as follows:

The equipment used was an Argus C3 camera with the Argus Techniscope ground glass attachment and stand as illustrated in figures 1, 2 and 3. The light source was two new number 1 photoflood bulbs in the Techniscope half moon reflectors directed toward a white screen (a white matte 16" x 20" mounting cardboard was used in this case). Therefore, the light coming into the camera was indirect, reflected light.

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Thanks must be given to Miss Carolyn Jennings, professor of bacteriology at Los Angeles City College for her cooperation and permission to copy her 3¼" x 4" Kodachrome originals upon which work this paper is based.

[1] Eastman Kodak Co. duplicating service described in instruction booklet enclosed with Kodachrome Type B film.

[2] McComb, Stanley J. Duplicating Color Slides. Journal of the Biological Photographic Association. June, 1941, Vol. 9, No. 4, P. 210-213.

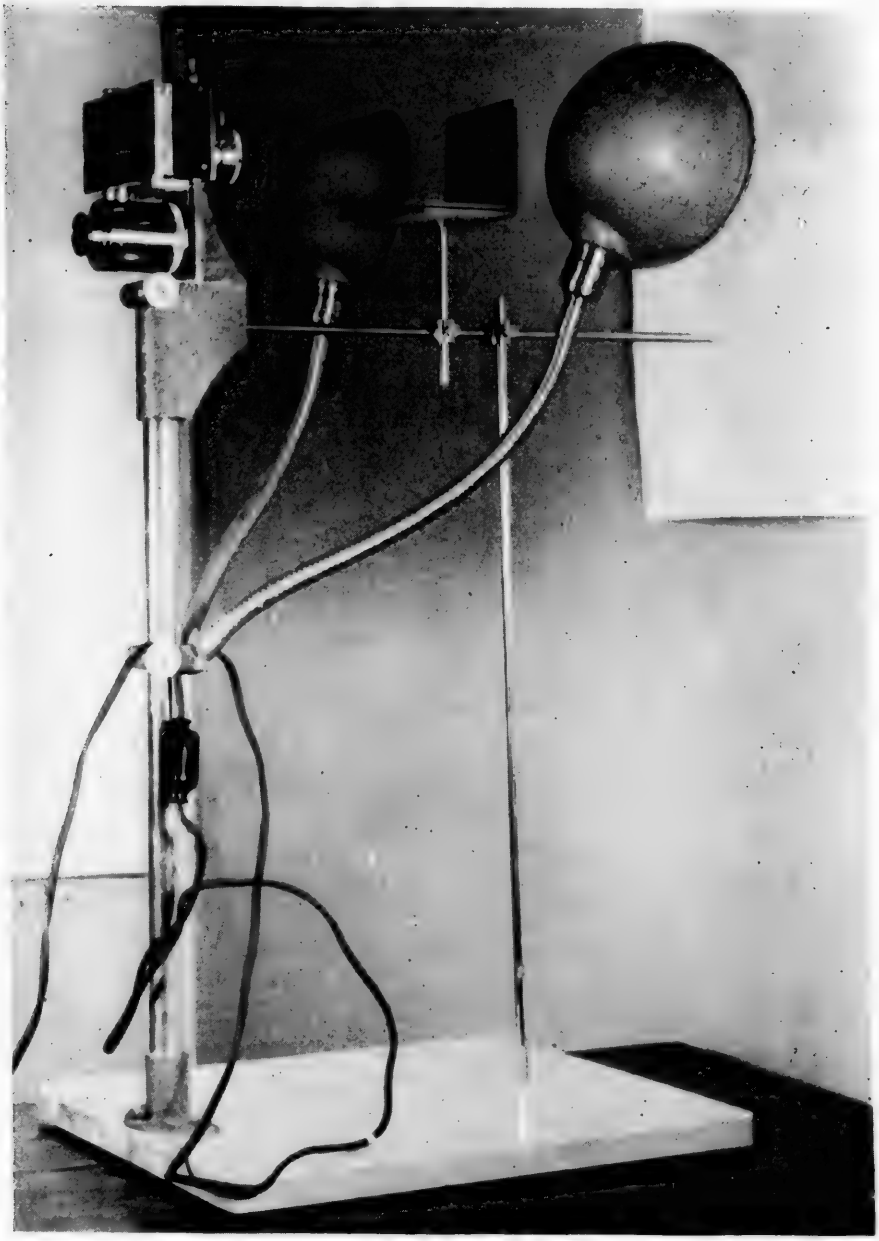

Fig. 1. Complete unit with slide to be copied in place. Ground glass slides in place behind the lens when needed, then slides back to camera position when exposure is to be taken. See Figs. 2 and 3.

The Kodachrome copies were 3¼" x 4" photomicrographic lantern slides made with Type B film. The Kodachrome film used in the camera was KI35A indoor film corrected for no. 1 Mazda photoflood bulbs.

A series of nine separate photomicrographs were copied, two sets of each one being made, therefore, necessitating two exposures per slide.

The exposure was determined and checked as follows: A roll of Eastman Super Sensitive Panchromatic film was placed in the camera. Meter readings were taken as described below, and a black and white picture of each slide was taken. The film was developed for 18 minutes

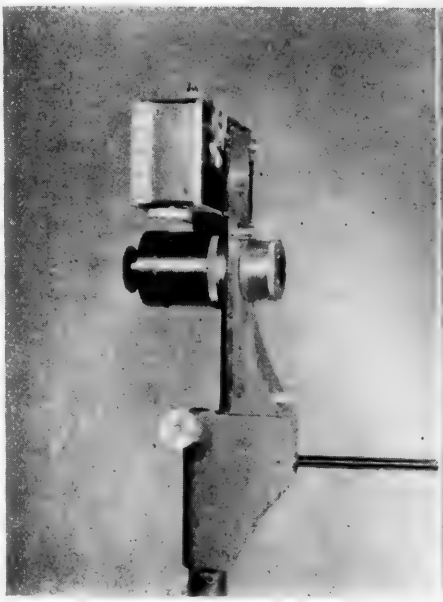

Fig. 2. Close-up of camera unit with ground glass in position behind camera lens.

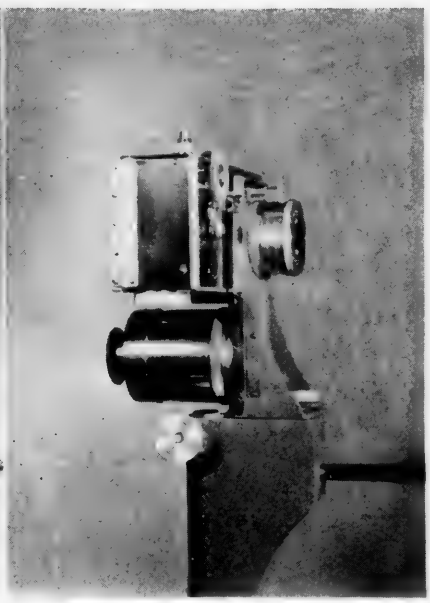

Fig. 3. Close-up of camera unit with camera in position behind lens.

at 68°F. in D76. The resultant black and white negatives were seemingly correct in exposure. The Kodachrome film was put into the camera.

As a means of checking, the meter reading was taken with the film speed indicator set at that of Kodachrome Type A film under tungsten light. The resultant exposure times and diaphragm openings were then

checked against those used with the Super Sensitive Panchromatic film. It just so happened that the emulsion speeds of Super Sensitive Panchromatic film and Kodachrome Type A film are the same. Therefore, the meter readings were the same. However, if a different black and white film were to be used, the differences in emulsion speeds and consequent exposure time could easily be computed from the meter.

A Weston Master light meter was used to determine the exposure times. The readings were taken with the meter held directly in front of the slide to be photographed, thereby measuring only the light coming through the slide and not around it.

The exposures of the slides for both the Super Sensitive Panchromatic film and K135A film comparatively set up are shown in fig. 4. The slight differences between the two sets of exposures are probably due to slight fluctuations in the line current as these pictures were taken in an apartment building at night.

When the Kodachrome reduction copies were received after being processed, each one was compared with its corresponding 3¼″ x 4″ original through the same light source. Generally, the color rendition and detail of the copy was exactly that of the original.

SUMMARY

A method has been described for making reduction 35 mm. Kodachrome transparency copies from 3¼″ x 4″ Kodachrome transparencies. The equipment used has been described and illustrated and the exposures, checked with those taken on Eastman Super Sensitive Panchromatic film, have been shown thereby illustrating the method of determining exposures.

EXPOSURE TABLE

Roll Exposure number	S. S. Pan. Film	K135A Film
1	1/10 sec.	1/11 sec.
2	1/15 sec.	1/15 sec.
3	1/7 sec.	1/7 sec.
4	1/9 sec.	1/9 sec.
5	1/15 sec.	1/15 sec.
6	1/12 sec.	1/10 sec.
7	1/18 sec.	1/8 sec.
8	1/8 sec.	1/10 sec.
9	1/10 sec.	1/7 sec.

Fig. 4. Comparative Exposures of the black and white and Kodachrome films used.

Photographic Processing Control

by Louis Paul Flory*

Part IV

V. Some Factors Affecting Reproducibility of Desired Density

Reproducibility of results in photographic processing control, both sensitometric and chemical, depends upon not only those factors mentioned in Section III (Part I) and Section IV (Parts II & III), but also upon the effects of agitation; reduction of density by fixing baths; drying conditions; storage conditions and age of unexposed material.

A. Agitation

Bloch[25] shows sketches of the emulsion surface of plates coated with "ordinary" and X-ray emulsions where the areas of different density (isopaques) due to non-uniformity in development are outlined. The plates were developed in a tray, using an irregular rocking method and also by employing a roller in contact with the emulsion. While the latter method could be used with plates developed singly, it is of little value in the usual type of developing procedure.

Crabtree[26] describes an underwater spray system for "wiping" the emulsion, as well as a number of squeegee devices. Ives and Jensen[27] discuss agitating devices with reference to motion picture processing machines.

Clark[28] gives an excellent description of non-uniformity in development, and describes a number of agitating devices. One handles four 5 x 7″ plates in a special rack, and might be adapted to handle sheet film.

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Received for publication November 1, 1943.

[25] Bloch, O.: "The Uniform Development of Dry Plates." Photographic Journal (London). Vol. LXI (December, 1921), No. 11, pp. 425-428.

[26] Crabtree, J.; "Uniformity in Photographic Development." Journal of the Society of Motion Picture Engineers. Vol. XXV (December, 1935), No. 6, pp. 512-522.

[27] Ives, C. E. and E. W. Jensen: "The Effect of Developer Agitation on Density Uniformity and Rate of Development." Journal of the Society of Motion Picture Engineers. Vol. XL (February, 1943), pp. 107-136.

[28] Clark, Walter: "The Technique of Uniform Development." Photo Technique. Vol. 2 (October, 1940), No. 10, pp. 54-58.

The ARL-Dietert film developing machine* is the only commercial machine with which the author is familiar that could be adapted to the development of glass lantern slide plates. The trays are arranged for horizontal development, but are too small to be used with a number of sheets of 5 x 7″ film.

There are a number of commercial agitators on the market for use with small developing tanks used in processing short lengths of motion picture film, but these would find only limited applications in the biological photographic laboratory.

Hand agitation is the method usually used. It is fairly successful provided the agitation is uniform and can be repeated with little variation. This is difficult to do, but is easier in the case of a fairly long development time than with a development time of only a few minutes. The nearer the gamma used in practice approaches the gamma infinity of the emulsion, the less will be the effect of any variation in the agitation. If it is customary to employ a number of different people to develop negatives, they should be taught to use the same method with respect to frequency and length of time when using intermittent agitation.

Assuming the use of properly compounded processing baths and control of photographic activity, little difficulty may be expected in attaining reproducible results if the agitation is reproducible. Some mechanical means of performing the agitation is desirable, but each laboratory must solve this problem in its own way, as negative sizes and procedures vary greatly.

B. Reduction of Density by Fixing Baths

Russell and Crabtree[29] studied the reducing action of fixing baths. Five different formulae were used, but the EK F-5 formula was not included as it had not been formulated at the time of the experiments. With a given formula, the following factors were found to be of importance:

1. Type of emulsion. Fine-grain emulsions were affected more than coarse-grain emulsions.
2. Time of fixation. Prolonged fixation greatly increased the reduction in the case of all baths tested.
3. Temperature. The rate of reduction increased with increasing temperatures.

* Manufactured by the Harry Dietert Co., Detroit, Michigan.

[29] Russell, H. D. and J. I. Crabtree: "The Reducing Action of Fixing Baths on the Silver Image." Journal of the Society of Motion Picture Engineers. Vol. XVIII (March, 1932), No. 3. pp. 371-397.

4. pH of the bath. Effect increased greatly for pH below 4.0 with baths tested.
5. Exhaustion products accumulated in the bath. As the concentration of silver halides in the bath increased, the reducing action decreased.
6. Agitation. Continuous agitation greatly increased the effect.

From the above it may be concluded that the time of fixation should not be longer than necessary to fix the emulsion; the temperature should be controlled; the pH should be measured frequently, as acetic acid carry-over from the rinse bath, in the case of printing, may be a factor; more reduction may be expected from a fresh bath than from one which has been aged and contains some silver; agitation, continuous or intermittent, should be uniform and reproducible.

C. Drying Conditions

White[30] concludes that uniform drying conditions are necessary in maintaining reproducibility. Slow drying at high relative humidities and temperatures usually results in an increase in density. Drying cabinets for negatives should be designed so that drying conditions are uniform.

D. Storage and Age of Unexposed Emulsions

Renwick[31] found that the degree of relative humidity affected the emulsion speed. Taking the normal speed as 100 at a relative humidity of 40 per cent, he found a decrease in speed of 25 per cent at a relative humidity of 80 per cent, and an increase in speed of from 6 to 18 per cent at a relative humidity of 20 per cent. The effect depended somewhat upon the type of emulsion.

Sheppard and Graham[32] showed that the effect of humidity depends upon the pH of the emulsion. With a constant emulsion pH, the effect depended upon the pAg (silver-ion concentration) of the emulsion. The loss in speed was greater for emulsions of higher initial pH.

From the above it may be concluded that the conditions of storage with respect to relative humidity are important factors in maintaining

[30] White, D. R.; "Drying Conditions and Photographic Density." Journal of the Society of Motion Picture Engineers. Vol. XIX (October, 1932), No. 4, pp. 340-345.

[31] Renwick, F. F.: "Effect of Humidity Upon Photographic Speed." Transactions of the Society of Motion Picture Engineers. (May, 1924), No. 18, pp. 69-72.

[32] Sheppard, S. E. and C. L. Graham: "Extragranular Factors in Photographic Sensitivity." Journal of the Franklin Institute. Vol. 230 (November, 1940), No. 5, pp. 619-641.

the emulsion speed—hence the reproducibility of desired density. Temperature effects are well known, and storage conditions, if not ideal, should be uniform.

Falling-off in emulsion speed due to aging in storage of photographic material, and the production of fog from this cause, are well-known phenomena. Little can be done to overcome this effect, but sensitometric tests will give the data necessary in using aged material.

VI. Discussion and Conclusions

Jones and collaborators[33, 34, 35] have made extensive investigations into the problem of film speeds. They[33] defined film speed in the following manner:

> The speed of a photographic material should be evaluated in terms of the MINIMUM exposure which will yield a negative from which an excellent print can be made.
>
> As a sensitometric criterion of effective camera speed the *exposure corresponding to that point on the D-Log E characteristic curve where the gradient is equal to three-tenths (0.3) of the average gradient of a log exposure range of 1.50 is proposed.*

Jones[33] also states that:

> Other fixed values of density have been proposed from time to time as criteria of speed. For instance, it has been suggested that the exposure yielding a density of 1.0 when the material is developed so that the straight-line portion of the characteristic curve has a slope of 1.0 be used as a criterion of speed. Other fixed values of density, such as 0.2. 0.3, etc., have also been proposed.
>
> From the standpoint of tone reproduction theory there seems to be no justification for the adoption of *any* value of density as a significant criterion of the speed of a photographic negative material. The primary function of the negative material is to record brightness differences existing in the scene. Density, *per se*, has no significance as an indication of the ability of the photographic material to perform this function. The value of negative density by which any particular object brightness is rendered, as, for instance, the deepest shadow, is of no consequence except insofar as it may have some bearing on the exposure time required to make a print from the negative.
>
> Tone reproduction theory indicates that there is only one characteristic of the negative curve that is significant in expressing the capacity of the material to reproduce brightness differences, and it is upon the way in which brightness differences are reproduced that the quality of the final positive

[33] Jones, L. A.: "The Evaluation of Negative Film Speeds in Terms of Print Quality." Journal of the Franklin Institute. Part I—Vol. 227 (March, 1939), No. 3, pp. 297-354. Part II—Vol. 227 (April, 1939), No. 4, pp. 497-544.

[34] Jones, L. A. and C. N. Nelson: "A Study of Various Sensitometric Criteria of Negative Film Speeds.." Journal of the Optical Society of America. Vol. 30 (March, 1940), No. 3, pp. 93-109.

[35] Jones, L. A. and H. R. Condit: "The Brightness Scale of Exterior Scenes and the Computation of Correct Photographic Exposure." Journal of the Optical Society of America. Vol. 31 (November, 1941), No. 11, pp. 651-678.

must depend. This characteristic of the D-Log E relationship is the "gradient" or "slope" since this determines the magnitude of the density differences by which *brightness differences* in the object will be rendered in the negative and eventually in the positive made therefrom. The term gradient is used in the previous sentence not in reference to the slope of a curve at a particular point, but rather it implies a consideration of the gradient characteristics throughout the entire used portion of the negative curve. There seems to be little doubt that the most logical and theoretically satisfactory solution of the speed evaluation problem lies in the development of a method by which the effective camera speed is expressed in terms of an exposure which is some function of gradient.

. . . It seems quite certain that the information the user of a photographic material, particularly the amateur, wishes to have about its sensitivity is how little exposure he can give and still obtain a a *good print*. It must be realized that the negative itself is only a means to an end and it makes little difference what its characteristics are, provided a print of satisfactory quality can be made therefrom. Under the vast majority of conditions almost any negative material is sufficiently sensitive so that exposures of satisfactorily short times can be made, even when using lenses of moderate or relatively small apertures. It is only under adverse conditions of lighting that differences between the speeds of commercially available negative materials become important. It seems justifiable, therefore, to conclude that the most satisfactory evaluation of *effective camera speeds* should be based upon the *minimum* exposure which will yield negatives from which *prints of satisfactory quality* can be made.

The author quotes Jones at some length because of the importance of his work, and the importance of film speed to the biological photographer, as well as because of the role which film speed plays in photographic processing control.

Jones was dealing for the most part with problems of the amateur. The test objects used in his experiments were exteriors, and represented typical subjects which amateurs would be likely to photograph. The biological photographer usually deals with entirely different types of subjects.

While the author agrees that the negative is only a means to an end, from the point of view of efficiency in production, with which every biological photographer should be concerned, the negative should fulfill certain requirements. The type of positive material used, and the use to which the positive will be put will, in a great measure, establish the required characteristics of the negative. While it may be possible to make excellent prints from negatives of various contrasts and density, through the use of various grades (contrasts) of printing material, such a procedure would be most inefficient, and should be an exceptional rather than a normal procedure in the biological photographic laboratory. If photographic processing control is of any use, it necessarily implies a desire for a product of uniform excellence, and

also efficiency in production. This, in turn, requires the production of negatives whose characteristics are such that they meet the requirements of the positive process, and production efficiency.

While density is not an indication of the ability of the negative material to record brightness differences in the object photographed, Jones admits it is of some significance in determining the exposure time required to make a print from the negative. This function of density is directly related to production efficiency, and can not be neglected. Naturally the value of the *desired density* need not be a *fixed value of density,* but its value will depend upon the processing procedures employed in a particular laboratory, as well as upon the nature of the material being photographed. The control of development contrast (gamma) will determine the degree in which the negative records the brightness differences in the object. The control of these two factors (gamma and density) is of primary importance in photographic processing control.

Assume that film speed is to be calculated on the basis of gradient as defined by Jones. This would require the construction of curves similar to that shown in Fig. 1 (page 106, Part I), and the use of a more elaborate sensitometer than the Eastman Gray Scales. The calculation of film speeds under these conditions is complicated, and for greatest efficiency requires more elaborate apparatus than will be found in the usual laboratory. Tuttle[36, 37] discusses the problem of determining the value of gradient, and describes the necessary apparatus and methods.

Jones and Nelson[38], in a most complete paper, discuss the problems of photographic printing, and describe apparatus and methods of sensitometric control which, unfortunately, are beyond the scope of the biological photographic laboratory.

Jones' methods of determining film speed and sensitometric control in photographic printing are probably ideal, but the apparatus required and the time consumed in making the determinations places these methods out of the reach of the usual biological photographic laboratory.

In this laboratory, during the thirteen years from 1928 to 1940 inclusive, 78 per cent of all photographs taken were made in the studio

[36] Tuttle, Clifton: "Methods and Instruments for the Determination of Photographic Speeds by Measurement of Relative Characteristic Gradients." Journal of the Optical Society of America. Vol. 29 (July, 1939), No. 7, pp. 267-277.

[37] Tuttle, C.: "Note on the Evaluation of Photographic Speed from Sensitometric Data." Journal of the Optical Society of America. Vol. 31 (November, 1941), No. 11, pp. 709-712.

[38] Jones, L. A. and C. N. Nelson: "The Control of Photographic Printing by Measured Characteristics of the Negative." Journal of the Optical Society of America. Vol. 32 (October, 1942), No. 10, pp. 558-619.

(excluding photomicrographs). During that time, 79 per cent of the studio photographs were made using a black background, such as is shown in Fig. 7 (page 116, Part I). This type of set-up, therefore, can be considered typical of much of the work done in this laboratory. Also, the great majority of all prints and lantern slides produced were made from these negatives. It seems logical, under these specific conditions, to consider the negative and positive exposure and development problems with this type of set-up in mind.

The brightness differences in the plants must be rendered in the negative in such a way that the print will give an excellent reproduction of the plants, and at the same time secure a completely black background in the print. This is accomplished through the correct choice of development gamma of the negative with a specific type of printing medium in mind. The density scale of the negative of Fig. 7 is 0.79. This density scale establishes the exposure scale requirement of the printing medium.

If prints of a calibrated Eastman Photographic Step Tablet are available for all the contrast grades of paper on hand, the correct grade of paper is that which has an exposure scale, between the tones desired in the leaves and the black background, matching the density scale of the negative. In the case of Fig. 7, this paper was Eastman Azo, F3, with an exposure scale of 0.78 between the limits mentioned.

So far as general photography goes, Fig 7 represents an unusual type of subject. The brightness differences in the object (plants) are slight, while a great deal of contrast exists between the object and the background. The background in the print must equal the maximum density of the positive material. Jones[38] used exteriors in which, in the case of all prints chosen as acceptable or excellent, the maximum print density never reached that of the maximum density of the positive material.

The biological photographer, however, is working in a specialized field, and what may be unusual in general photography may be commonplace with him. While the set-up in Fig. 7 represents a special case, similar case or their "converse" (objects against a dead white background) are encountered in most types of biological photography.

The author believes, therefore, that the characteristics of the negative are of great importance in producing excellent prints efficiently, and that the methods of determining film speed described in Part I, with the use of a *desired density* for the most important part of the object photographed is of great help in the use of *photographic processing control.*

The methods described under Chemical Control are also necessary for the greatest efficiency. The system has been in use in this laboratory for two years, and has resulted in a great improvement in quality and efficiency. The equipment required is not too elaborate nor expensive for the usual biological photographic laboratory.

Appendix D. Method of Measuring pH of Rinse and Fixing Baths

One of the methods of measuring pH best adapted to the photographic laboratory employs colored glass standards together with standardized indicator solutions. The Hellige Hydrogen-Ion Comparator, shown in Fig. 12, is used in this laboratory. For other useful methods see Chapter IV of LaMotte, Kenny, and Reed[39].

Fig. 12 shows the comparator equipped with a special lamp, L, and mounted on a stand. A color disc, containing the colored glass standards, is shown at D, and a bottle of indicator solution at S.

Each color disc covers a specific pH range. The discs employed in this laboratory are as follows:

No.	Description	pH Range	Use
620-11	Hellige Orange	2.6-4.2	Rinse baths
145-D	Bromcresol Green-D	4.0-5.6	Fixing baths
155-D	Bromcresol Purple-D	5.2-6.6	Fixing baths

The discs must be used with the proper indicators which have the following Helige numbers: 675-11 145-S; 155-S; corresponding to the numbers on the discs. The lamp, L, is equipped with a special filter for use with the above discs.

To measure pH, using a transfer pipette, pipette 5 ml of the solution to be tested into one of the glass cells, shown at C, and place this cell in the left-hand opening in the top of the comparator. This brings the cell and the test solution between the lamp and the colored glass standards in the color disc. The image of the contents of this cell is viewed in the left-hand portion of the eyepiece shown at E. The proper amount of indicator solution, 0.25 or 0.5 ml, is pipetted into the other glass cell, using a measuring pipette, and 5 ml of the solution to be tested is added, using a transfer pipette, being sure that the indicator and the test solution are thoroughly mixed. This cell is then placed in an opening in the top of the comparator to the right of the first cell. The image of the contents of the second cell is seen in the right-hand portion of the eyepiece, and the position of the cell places its contents between the lamp and the central opening in the color disc.

The edge of the color disc protrudes on the right side of the comparator. This edge is used to revolve the color disc, bringing different color standards in the light path of the first cell. In this way, the first cell with the solution to be tested plus one of the color standards is compared in the split-field eyepiece E with the second cell containing the solution to be tested plus the indicator solution. When a color match is found in the eyepiece between the two fields, the value of the pH is read through the small opening in the lower right-hand corner of the comparator.

Should the match take place at either extremity of the pH range of the disc, the disc having the next higher or lower range, together with the proper indicator solution, should be used to check the reading.

[39] LaMotte, F. L., W. R. Kenny, and A. B. Reed: "pH and Its Practical Application." The Williams & Wilkins Company. Baltimore. 1932.

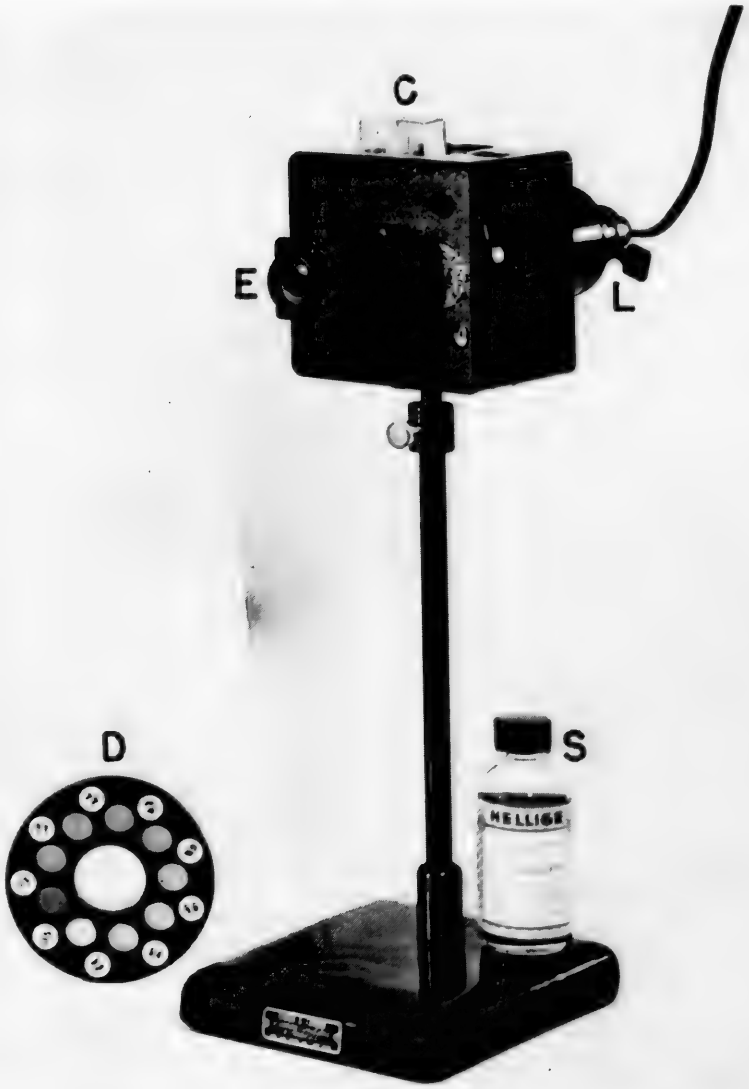


Fig. 12. Hellige Hydrogen-Ion Comparator on stand. C—glass cells; D—color standard disc; E—split-field eyepiece; L—lamp; S—bottle of indicator solution.

The operation of the comparator is relatively simple and only a short time is necessary to complete a determination.

APPENDIX E. SILVER CONTENT OF RINSE AND FIXING BATHS

I. Colorimetric Method.

The colorimetric method of determining the silver content of rinse and fixing baths (in grams per liter) depends upon the reaction between silver and sodium sulfide. The formulae to follow are taken from Weyerts and Hickman[18] and were intended to be used with their Argentometer. They are here adapted to be used with the Lumetron Colorimeter (Model P-AC), shown in Fig. 13.

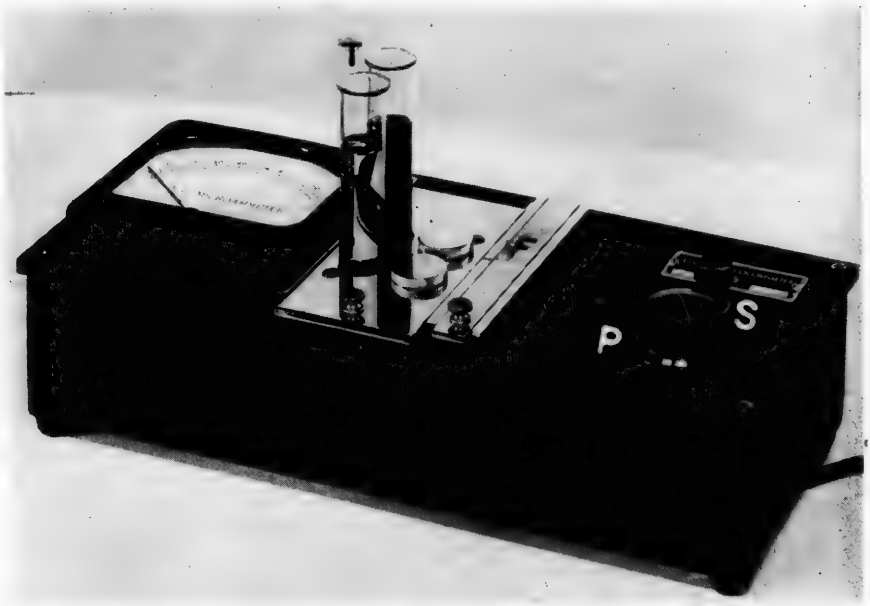


Fig. 13. Lumetron Colorimeter (Model P-AC). F—filter block; P—potentiometer knob; S—switch; T—test tubes.

Three testing solutions are necessary:

Solution A:

Citric acid	9.0 grams
Sodium citrate	100.0 grams
Water to make	1.0 liter

Solution B:

Gelatin	4.0 grams
Water to make	1.0 liter

Clove oil (a few drops for preservation)

Soak the gelatin in a small amount of water until swollen; then heat gently, stirring, until all is in solution; dilute to proper volume with water, pour into a bottle, add the clove oil, and shake a few times.

Solution C:

Sodium sulfide (C.P. crystals)	10.0 grams
Sodium sulfite (anhydrous)	6.0 grams
Water to make	100.0 ml.

Since the meter on the Lumetron Colorimeter is calibrated in microamperes, it will be necessary to construct calibration curves for the rinse and fixing baths, calibrating the meter readings in microamperes in terms of the silver content in grams per liter. A calibration curve for fixing baths is shown in Fig. 14.

Add 1.574 grams of silver nitrate ($AgNO_3$) to a small amount of fresh SB-1 rinse bath, and after the silver nitrate is dissolved, make up to 1 liter by the addition of more rinse bath. This gives a rinse bath with a silver content of 1

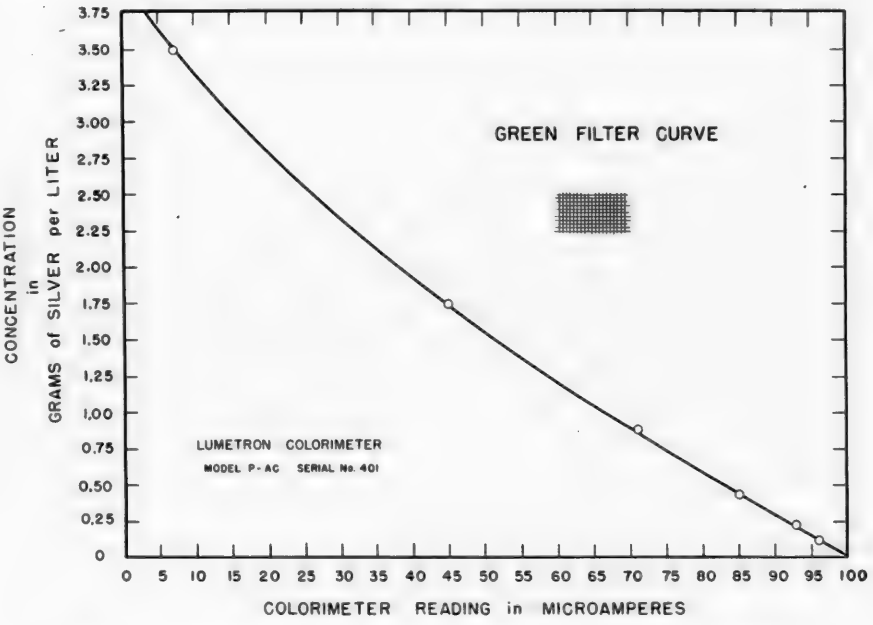


Fig. 14. Colorimeter calibration curve for fixing baths for green filter. The grid shows the fineness of the coordinate paper on which the curve should be plotted—20 x 20 to the inch.

gram per liter. If a higher silver content is desired, multiply 1.574 by the content desired. In this laboratory the silver content of rinse baths used in print processing never reached a concentration of 1 gram per liter.

In the same way, add 12.185 grams of silver bromide to a small amount of fresh F-5 fixing bath, dissolve, and make up to 1 liter by the addition of more fixing bath. This gives a fixing bath with a silver content of 7 grams per liter which is in excess of the allowable concentration even in two-bath processing of prints.

Portions of the rinse bath containing 1 gram of silver per liter are taken and varying amounts of fresh rinse bath added to give a series of rinse baths with decreasing silver concentrations. Such a series as: 1 gm/1; 0.5 gm/1; 0.25 gm/1; 0.125 gm/1; 0.0625 gm/1; 0.0313 gm/1; 0.0156 gm/1.

The same thing is done with the fixing bath containing 7 grams of silver per liter. The suggested series is: 7.0 gm/1; 3.5 gm/1; 1.75 gm/1; 0.875 gm/1; 0.438 gm/1; 0.219 gm/1; 0.109 gm/1.

Transfer 2 ml of the rinse bath containing 1 gm/1, using a transfer pipette, to a 50 ml graduated cylinder. Add 5 ml of solution A, and 5 ml of solution B, using transfer pipettes. Solution A buffers the rinse bath sample to a pH of approximately 5.8, and solution B adds gelatin in excess of that which might normally be present.

Add distilled water up to the 50 ml mark on the cylinder and stir with a clean glass rod. Pour 25 ml of the solution from the cylinder into one of the test tubes shown at T in Fig. 13. Place this tube in the front hole of the tube block of the colorimeter. Pour the remaining 25 ml of the solution into the other test tube, and add 0.5 ml of solution C. Stir well, and place this second tube behind the first tube, as shown in Fig. 13. The silver in the rinse bath in the second tube reacts with the sodium sulfide in solution C, and the sample turns a brownish color, the depth of color depending upon the amount of silver present in the sample.

The filter block F holds three filters—red, green, and blue. The usual procedure would indicate the use of the blue filter for the brownish color of the solution of silver sulfide. The author recommends the use of the blue filter for rinse baths which do not have a high silver content, but prefers the green filter for fixing baths because of the shape of the calibration curve, shown in Fig. 14.

The colorimeter is connected with the source of electric supply, preferably through a voltage stabilizer. The switch S is depressed, lighting the exciter lamp, and, by observation, the blue filter is brought into the light beam by means of the knob on the front of the filter block which is used to shift the position of the block after raising the block slightly.

The knob on the front of the tube block is used to place the first test tube, which does not contain any of the sodium sulfide, in the light beam. While depressing the switch S with the third finger of the right hand, grasp the knob P and turn it in the direction necessary to adjust the needle of the microammeter to full-scale deflection (100). When the needle no longer fluctuates shift the test tube block to bring the second tube into the light beam. The needle will show less deflection depending upon the amount of silver sulfide. Take the reading of the microammeter and record it together with the silver content of the sample.

Repeat the above procdure for the remaining samples of the rinse bath. From the data obtained plot the calibration curve on rectangular coordinate paper. From this curve, the silver content of any unknown rinse bath sample may be read after determining the reading of the microammeter on the colorimeter.

The entire procedure must be repated using the fixing bath samples, and employing the green filter. The calibration curve obtained in this laboratory for fixing baths with the green filter is shown in Fig. 14, which is plotted on paper 20 x 20 to the inch. The choice of scale for the coordinates must comply with the accuracy of the data.

Once the work of obtaining the data is completed and the calibration curves plotted, it takes but a few minutes to make a determination of the silver content of a sample of rinse or fixing bath. The accuracy of the method is sufficient for most photographic purposes, but it is necessary to use clean glassware and distilled water.

II. Titration Method*

The titration method of determining the silver content applies to fixing baths only, and requires more of the sample, besides taking much more time than the colorimetric method. While capable of greater accuracy than the colorimetric method, the determinations should be made in triplicate in order to assure the greatest accuracy. It may be used as an occasional check on the colorimetric method.

Take 50 ml of the fixing bath to be tested and place it in a 600 ml beaker. Add 20 ml of a 30 per cent solution of hydrogen peroxide. This must be done slowly, as considerable heat is generated. The solution is then boiled vigorously for 5 minutes to precipitate the silver as Ag_2O probably.

The Ag_2O is filtered through a 9 cm., No. 1 filter paper. The precipitate is then placed, together with the filter paper, in a 400 ml beaker. Add 10 ml of concentrated nitric acid and 20 ml of distilled water. Boil vigorously to dissolve the Ag_2O and form silver nitrate ($AgNO_3$). The solution is boiled down to a volume of 5-10 ml, or until the excess nitric acid has boiled off. This is essential, since the titration can not be carried out in a strongly acid solution.

The above solution is filtered to remove the filter paper, and is made up to a volume of 100 ml by the addition of distilled water. Using a measuring pipette, add 0.5 ml of a saturated solution of iron sulfate—$Fe_2(SO_4)_3$—as an indicator.

A burette is filled to the zero mark with a tenth molar solution of potassium thiocyanate (0.10M KCNS), and the sample is titrated with the KCNS until a faint permanent pink color is secured. The reading of the burette in milliliters is recorded. This reading multiplied by the silver equivalent of the KCNS solution gives the silver content of the sample per 50 ml. This amount multiplied by 20 gives the concentration in grams per liter.

The KCNS solution is made by dissolving 9.717 grams of KCNS in a small amount of distilled water, and making up to 1 liter. One milliliter of this solution should be equivalent to 0.010788 grams of silver, but this should be checked by titrating 20 ml of a standard silver nitrate solution with the KCNS solution, using a few drops of the iron sulfate as an indicator.

To make the standard silver nitrate solution, dissolve 16.989 grams of $AgNO_3$ in a small amount of distilled water, and make up to 1 liter. This solution contains 0.010788 grams of silver per milliliter, provided the silver nitrate used is of the highest analytical quality.

If the KCNS solution is of the correct strength, it will take 20 ml of the KCNS solution in the titration of the 20 ml of the standard silver nitrate solution. If this is not the case, multiply 0.010788 by 20, and divide by the number of milliliters of the KCNS solution used in the titration. For example: suppose it was necessary to use 21 ml of KCNS solution; $0.010788 \times 20/21 = 0.010292$ grams of silver. The molarity of the KCNS solution would then be 0.0954 instead of 0.10. The silver equivalent of 0.010292 grams of silver per milliliter of KCNS solution would then be used in calculating the silver content of the sample.

III. Specifications for the Safe Upper Limit of Silver Content of Fixing Baths

The following recommendations are taken from Table X of Crabtree, Eaton, and Muehler[16], and are confined to commercial fixing and washing as defined by these authors— an expected keeping life of a few decades or less. For the specifications for "archival" use, see the above reference.

The specifications are given for two types of processing: one employing a single fixing bath; one employing two fixing baths where the second fixing bath

* Devised by Dr. Edward K. Harvill, Boyce Thompson Institute for Plant Research, Inc.

is placed in the first position when the first fixing bath is discarded. The use of two fixing baths is desirable if there is sufficient space in the processing room to accommodate the necessary tanks, and if the amount of work justifies the expense of the additional equipment.

It is assumed that the pH of the fixing baths will be maintained below 4.9.

Single Fixing Bath

Type of Emulsion	*Upper Limit in grams per liter*
Film	1.5
Paper	0.3

Two Fixing Baths

First Bath:	
Film	6.0
Paper	2.0
Second Bath:	
Film	0.5-1.5
Paper	0.3

The figures for the number of films or prints which may be processed have been omitted because of the lack of correlation found between the number of prints processed in a bath and the silver content of the bath, which was discussed in Part III.

THE END

☆

BUY WAR BONDS

***Every* PAY DAY**

☆

Design for Small Darkroom

Arthur W. Proetz, M. D.*

THE darkroom here described was designed with two purposes in view: the conservation of time and energy, and technical efficiency. The equipment is largely standard and there are few gadgets. The effectiveness of the arrangement depends mainly upon the distribution of equipment, switches, storage space and illumination. Everything has been placed as nearly as possible in logical relationship to the rest.

Figure 1 was arranged to show the maximum detail but gives a false impression of the size of the room. The over-all dimensions of the room are 8′ 6″ x 11′ 6″. The free floor space is 4′ x 8′ 6″. The walls are treated with a flat, non-reflecting paint and are green to give maximum illumination with a safe-light. The floor is covered with an acid-proof, fire-proof composition tile and all woodwork is treated with a dull enamel of the same color as the walls.

A clear description of the details can best be given by referring to the illustrations.

Figure 1. Left Panel and Figure 2

These figures illustrate the south or "dry"side. On the left end of the table is a film dryer. Roll film is dried in the tube as usual. For cut film the metal tube is removed from the blower and the blower is set beneath the films, still supported in their hangers, which are thrust into holes made for them in the wall at this location. The top of the blower is covered when not in use to prevent the collection of dust.

Next, to the right, is a simple apparatus for copying and animation. It consists of a flat metal plate which slides up and down on two vertical rods and can be fixed in any position. The various cameras are attached to this plate and suitable perforations are provided for them. Small metal guide strips keep the cameras vertical. This apparatus is further described under Figure 4. The supporting rods are attached at the top to a projecting shelf which is of sufficient weight to eliminate

*1010 Beaumont Bldg., St. Louis, Missouri. Received for publication September 13, 1943.

vibration. Above this shelf are cupboards which are in contact with the cooling-system ducts of the building and furnish an excellent cool storage space for solutions.

The small view-box below it can be tilted downward to illuminate the work while copying but is used chiefly to identify films during the

Left Panel *Central Panel* *Right Panel*

Figure 1

process of printing. The films are stored in drawers shown in the lower left hand corner of Figure 2. The recess just to the right holds the print trimmer. Below this for printing paper, are light-tight drawers, the covers of which close automatically when the drawer is closed. These can be seen in the lower right hand corner of Figure 6. Here also is a wide drying closet with an exhaust fan and slots cut in the door for circulation. It contains piles of drying blotters and separators. To the left of the 35 mm. enlarger is a hygrometer. Attached to the other enlarger is an electronic timer. This is hardly necessary for ordinary work but is a great convenience when a series of pictures is required to have the same density. The standard supporting the enlarger is bolted to the table top and to the projecting shelf above which makes it perfectly rigid.

The current from the outlets to the two enlargers is controlled by the two switches, left and right, in the face of the table at the extreme bottom of the illustration, Figure 2. The center switch controls the

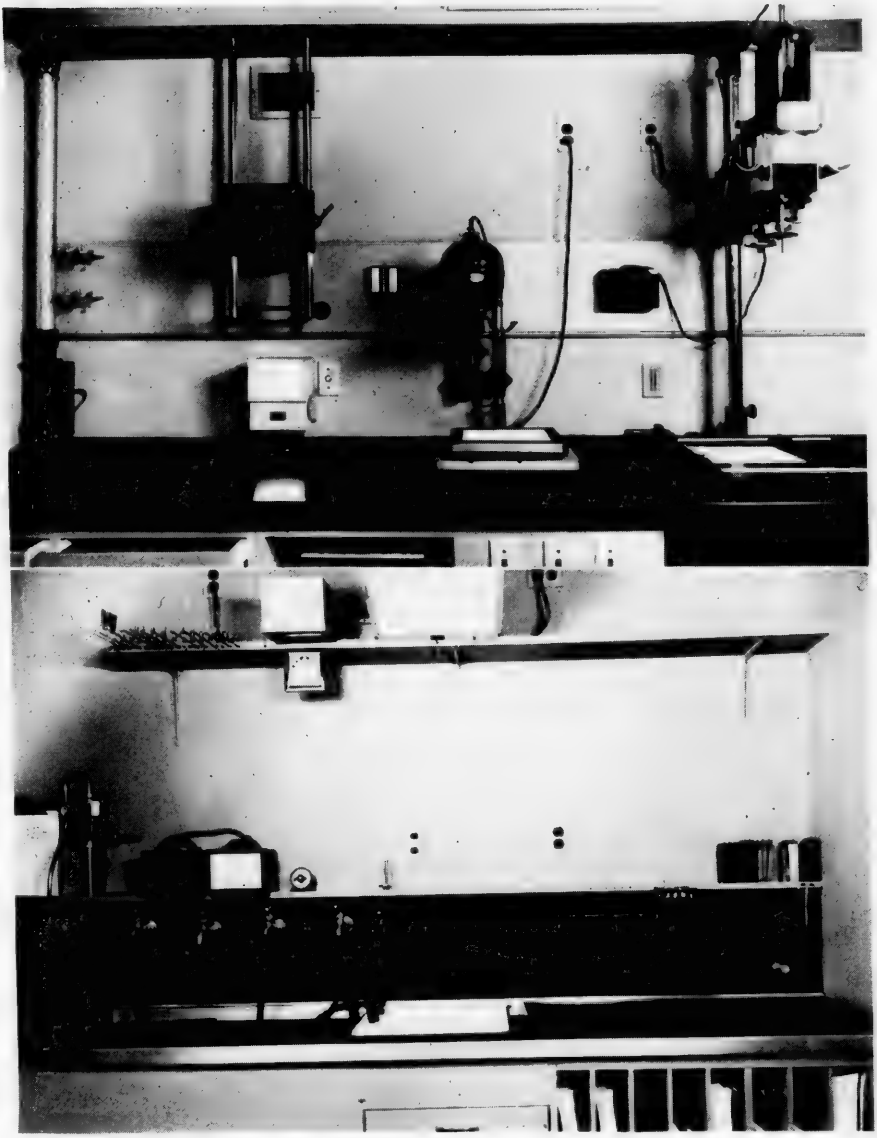


Figure 2 (upper)

Figure 3 (lower)

ceiling light. The tumbler is sharply notched so that it will not be confused in the dark with the enlarger switches. Beneath the enlarger is a space illustrated in Figure 5. Beneath the far end of the table are two shelves for the bulkier apparatus. The table top is finished in lacquer and rubbed.

FIGURE 1. CENTRAL PANEL

The west wall is occupied largely by two sets of storage cases. The one on the left, or dry side, is devoted to sensitive materials—filters, masks and other equipment required for printing. The case on the right is *entirely separated* from the other and contains all chemicals and small apparatus used on the wet side such as developing tanks, hangers and funnels.

The towel suspended from the left cabinet is in a convenient position as one turns from the sink and the developing trays to the dry side.

Fastened to the case just above it is a small filing cabinet, containing a card index of formulae and other technical data.

FIGURE 1. RIGHT PANEL AND FIGURE 3

In the far corner, on and under the table top, are large bottles containing stock solutions. Across the left end of the sink is a developing tank having three compartments each accommodating a dozen films on hangers. Just above it is a chart of developing times for various sensitive materials. (The apparatus with the gauge and the curved metal tubing is a water suction pump installed for purposes other than photographic.)

Next on the narrow shelf are a safe lamp, a clear lamp, a timer, a thermometer and a thick soft-leaded pencil for marking wet prints.

The four taps are for tap water, icewater, hot water and another for tap water which is attached to the print washing siphon.

The sink is floored with the usual "duck-boards". The washing tray stands on the drip-board which is four inches below the level of the table. The table top and the splash board at the back are covered with rubber and edged with metal.

The right end of the table is devoted to loading films. Small holes are drilled into the face of the narrow shelf to accommodate the ends of the film hangers, which are thus kept off the table while the films are being unloaded in the dark, thus avoiding scratching and the accumulation of dust.

In the far corner are a small crank and spindle for 35 mm. film, and scissors.

Beneath the sink are two drawers for clean and soiled towels and a large waste receptacle fastened to a door hinged at the bottom.

To the right of this are compartments of various sizes to accommodate the developing trays.

The shelf above holds a large floodlight (an x-ray viewing box with a large light bulb), a safe lamp for printing, with an electric clock immediately beneath. Into the face of the shelf at its left end are drilled a number of holes which also accommodate the ends of the film hangers. Films are placed here to dry. They are placed so that they project upwards from the hanger. In this position the hanger clips help to drain off the water which accumulates at the lower edge. If by any chance there should be enough moisture to fall away it drips into the sink. The two lamps are controlled by the double switch in the center of the wall. The outlet to the right accommodates an electric print dryer.

FIGURE 4

This illustrates the camera and lamps set up for copying or for animation.

The lamps are daylight fluorescent tubes. Reflectors were made from biscuit tins and they are set at the proper distance and height to insure even illumination over the drawing board which is clamped to the table by means of small studs similar to those holding the lamps.

As the camera field is mapped on the drawing board and the proper height is marked on the vertical steel rods, conditions of focus and illumination remain standard and the whole apparatus can be set up, once the camera is loaded, in something under a minute. Since all the apparatus, excluding the camera, is kept in the drawer immediately below, very little time is lost and a first-rate negative can be turned out in a very few minutes.

Details of the ventilating slots in the door of the print drying closet can be seen at the bottom of the illustration.

FIGURE 5

The portion of the table top immediately underlying the enlarger is removable. It can be placed half way or all the way to the floor, to

facilitate making enlargements of more than the usual size. A foot switch is shown plugged into the receptacle at the left which can be

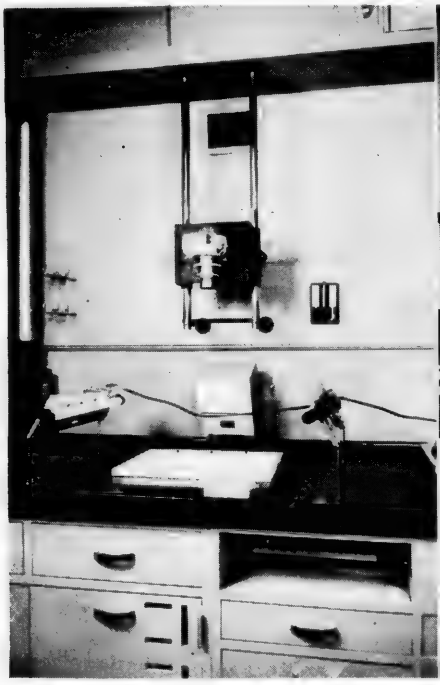


Figure 4

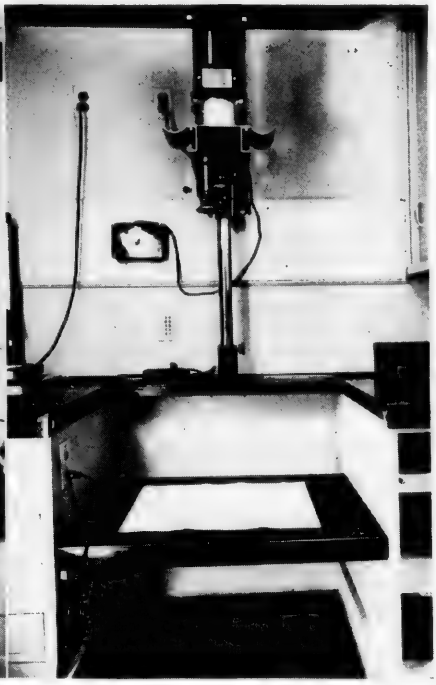


Figure 5

made to control any of the apparatus when the hands are occupied in dodging or masking.

The fourth wall, not shown in any of the illustrations, is provided with the usual maze. Toe recesses are provided at the foot of all cabinets and tables which materially reduce fatigue.

The several cabinets have sliding panels for doors which prevents running afoul of them in the dark.

All apparatus with the exception of the vertical camera track is standard equipment. Needless to say it is all *ante bellum!*

CHATS WITH THE EDITOR

SCIENTIFIC PHOTOGRAPHY IN CHILE

In Chile, there is no doubt that amateur and professional photographers are quite up-to-date. Throughout the year one can find opportunities of seeing pictures at the various exhibitions. Chile's beautiful coast and her snow-covered mountains are an irresistible source of inspiration to picturing. Amongst the photographs of amateurs as well as those of the professional protographers one often find masterpieces which would be striking anywhere.

But the branch of photography in which I am specially interested is "Photography in scientific work," such as photomicrography, photography in hospital-work, surgery, veterinary medicine, botany, geology and so on.

So far as I know, there are few people working steadily in these fields. In spite of the great progress in our days and the fact that in Chile science and medical work are quite up to date, and much investigation work is being done, very few scientific men apply photography as an aid to their work. Lectures and conferences are very seldom illustrated by lantern slide projections. Some scientists apply the old-time method of drawing, or reproduce pictures that appear in some other scientific works. But only a few scientists show original photographs taken of the work.

Why has scientific photography in Chile not obtained more recognition? The usual answer is that although photography is a most interesting pastime it is not suited for scientific work or it is too expensive, or certain things can simply not be photographed. If any doubts are expressed on this point of view, photographic departments are shown that have been created some time ago, but that now are out of use. Apparatus and out of date materials lie piled up in a corner, worthless and neglected.

All these things, apparatus, materials, and laboratories demonstrate that once there had been interest in photography. These things had

at one time been bought, these departments had been installed. But the worker had not been successful and so the interest died down and the hope and the belief in scientific photography disappeared, too.

But why was work so unsuccessful? Well, photography in scientific work means more than mere enthusiasm. Many pictures must be taken which may be of no interest to the photographer himself, either from the point of view of a special technique or as a specially interesting case. Throughout the year picture after picture is taken and filed. There is little possibility of boasting about masterpieces, and even sometimes there is little recognition of the photographic work by the very person who wanted it.

Photography in scientific work should take the place of a good helpful friend. It will achieve and keep the different steps of the scientists' process. If some reference is wanted of a certain process, the pictures are there to be used. There is no better testimony to a scientist's work than a good picture. And in order to take good pictures of those subjects, a person to whom photography does not mean a hobby, but his life's work, is needed. A serious continuous scientific work cannot be accompanied by the varying enthusiasm of the Sunday Amateur. It is too dry and at the same time too hard to be carried out as a secondary occupation.

Photography is a real work and has to be taken as a real work. Every real work needs a real worker. It is because of this lack of professional workers in the field of scientific photography that the laboratories are forgotten and neglected, that the apparatus lie piled up in a corner and that the materials are out of date.

L. Grabherr, Avenida Septiembre 3232, Santiago, De Chile

Confusion between the words "microphotography" and "photomicrography" and between "microcinematography" and "motion picture photomicrography or cine photomicrography" in the past has lead to continued misusage in the present.

Chalmer's Technical Dictionary, Macmillan Co., 1940, gives the following definitions: "*Microphotography*—the production of minute prints or transparencies from normal negatives; *Photomicrography*—the production of normal negatives and prints of objects of microscopic dimensions".

Wall's Dictionary of Photography, American Photographic Publishing Co., 1940, states: "Micro-photography—the reproduction of

photographs on a very minute scale; photo-micrography—the photography of minute objects by the use of a microscope in conjunction with a camera".

In the Amateur Photographer and Cinematographer, *86*: November 16, 1938, on page 561 the editor writes as follows: "We shall have to get ourselves accustomed to this word, so often used wrongly. " 'Photomicrography' means the enlargement of microscopic objects and the projection of the enlarged image on sensitive film. 'Microphotography' means what it says, the photography of objects on a microscopic scale".

The definition of photomicrography in Webster's dictionary as well as the above definition by Wall implies that the use of a microscope is necessary to produce a photomicrograph. A magnification of 20X, obtained with a camera lens, not involving a microscope, might reasonably be called a photomicrograph.

Misusage is spreading. In the Transactions of the American Society for Metals *29*: 1941 on page 733, we find this sentence, "*Microradiography* grew out of the desire to obtain and view radiographic images of heterogeneous objects of small size". Read the above definitions and you find the term microradiography is erroneously used. *Microradiograph* should be reserved for use when referring to radiograph which has been reduced in size. A good example of the latter is typified by the microfilms of chest radiographs which have been employed by the military medical branches.

A *Macrophotograph,* from common usage, might be considered to be a photomicrograph made at a magnification between 10X and 1X. Metallurgists frequently use the above term when referring to photographs at unit magnification. Possibly *macroradiography* could be substituted for microradiography in the above sentence quoted. The term *macrophotograph* is sometimes used by biologists to denote small reductions instead of magnification,—another source of confusion.

Likewise, the term *microcinematography* has been used indiscriminately usually when either cine photomicrography or, if you prefer, motion picture photomicrography was meant.

This is a plea to all editors and authors to watch the terminology, before usage renders these incorrect terms too familiar and makes a change to the correct terminology still more difficult.

Elsie L. Garvin, Librarian, Research Library, Eastman Kodak Co.,
Kodak Park, Rochester, New York.

President's Address

Ferdinand Harding*

It has been said that we, as an Association, do not appear to give the present war a second thought. A thoughtless perusal of our Journal might give such an idea to many. Much of the research now going on must remain a secret until after the war, then we will have much new material to discuss and learn to use. I sincerely hope this will explain to some of our members why more material pertaining to the war is not published.

Those of us who are doing full or part time medical photography certainly know that something is wrong with the world. It becomes, for many of us, a large undertaking to get enough material to function in even a halfway normal manner. There are those who can see no reason for curtailment or rationing of film. To those persons I can only say that if they knew of all the new and necessary uses of photographic materials by our Armed Forces, they would wonder that any material was available for us.

It must be remembered that we are engaged in what is to the layman a nearly unknown branch of photography, so it is not remarkable that some local WPB boards have rejected applications for material as unessential. In this connection, several times in the past year we have attempted to find some way of keeping the members informed about WPB regulations regarding the rationing of photographic materials. This has been very hard to do because of the changes made in regulations from time to time. The different ideas held by local WPB offices as to what constitutes essential use of material has caused many anxious moments to some of our members. If anyone is still having difficulty it might be helpful to write our Secretary, Miss Shiras and give her full details; her advice, based on past experience should be of considerable aid.

The war has caused many gaps in our ranks. We are proud of what little we are permitted to know of what these members are accomplishing, and we know that the knowledge they are gaining will be passed on to us when it can be released. The Association shares a little in the accomplishments of Captain Creer and his Medical Photo-

* The Children's Hospital, Boston, Mass. Read before the 13th Annual meeting of the Biological Photographic Association, Princeton, N. J., Sept. 9, 10, 11, 1943.

graphic Units. Quite a few of our members are in those units. Several other members are engaged in research, photographic and otherwise, for war purposes. Some of the new methods these people are working on will be of the greatest benefit to biological photography. It is my firm belief that the use of biological photography will increase by leaps and bounds when peace comes. The rapid advancement of science is one of the few benefits of war. Under the pressure of war conditions scientific knowledge is speeded up and pooled, and out of the combined efforts of many brilliant scientists, working together, come potential benefits that in peace time would take years if indeed they ever came into being.

In the past year the Association has been asked to lend its name to various causes and "isms". At no time has such permission been granted. It would be very poor publicity for us. We are in need of good national publicity, but it must be of the right kind, or it will do us harm. We should be happy to talk with any member having ideas on this subject. Ours is an Association of men and women of many races, nations and creeds. We are a scientific group, bent upon improving our knowledge, that we may add our bit to the advancement of science all over the world. We cannot permit the name of the Association to be coupled with this or that selfish cause.

For some time past we have had three membership classifications. The officers and directors believe that the Associate class has proven a drawback, and has recommended to you that an amendment be made to the Constitution eliminating such a classification. At a later date we will try to introduce a classification for advanced workers, but the proper time has not yet arrived.

Our membership has grown at a reasonable rate, considering world conditions, and we are healthy financially. It is my belief, and it is shared by others, that there should be a larger number of members in the Association from our sister countries in South America. I believe that after the war we should look into this matter. There are many hospitals and Universities and many excellent photographers in South America, and they should be brought together for mutual benefit.

Our Association is being copied with some additions in England. One of our members over there, Mr. Weston, writes that the Association of Scientific Photographers is in the process of being formed. As they are proceeding along very similar lines to our own, I believe we should feel very proud that our group is considered so highly useful that a like organization is found necessary over there.

Association News

THE 1943 CONVENTION AT PRINCETON

The meeting had to be somewhat impromtu this year because of war conditions. But the three days we spent at Princeton under the Chairmanship of Mr. Julian Carlile were as interesting and enjoyable as any we have had. In order to place the program on record for future reference, we give it in full at the end of this account.

At the annual business meeting Dr. Oscar Richards, Chairman of the Motion Picture Committee, could give only a partial report as the titles of new films made by members are still coming in. His report will be published separately when this list is more complete.

It was voted unanimously: (1) to drop the category of "associate member" because it had not proved a useful classification, and to consider all members active; (2) to make the three most recent ex-presidents ex-officio members of the Board of Directors. Capt. Ralph Creer, Mr. Louis Schmidt and Mr. Leonard Julin are our three ex-presidents who now automatically become members of the Board.

The terms of all officers and of three directors (Capt. Creer, Mr. Schmidt and Dr. Richards) expires this fall. Of the Directors, two had just been placed ex-officio on the Board. Mr. Haulenbeek read the names submitted by the Nominating Committee to fill the expired offices as follows:

President ---------- Mr. Frdinand Harding
Vice President ---------- Mr. Henry Morris
Secretary ---------- Miss Anne Shiras
Treasurer ---------- Miss Stella Zimmer
Directors ---------- Dr. Oscar Richards,
Mr. Leonard Perskie, Mr. Arthur Smith

The questionnaires sent out to all members, and the division of members into fields of interest, were brought up as unfinished business. Mr. Arthur Smith, who took over the questionnaires when Lt. Eddy went into the Army, reported that interesting information was coming in. A system of notation was being devised so that details about a member's field, type of equipment, etc. could be contained on a small card. These cards are now in the process of being filled out.

The election of officers was held the following day, when the motion was passed unanimously to instruct the Secretary to cast one ballot for the officers and directors named by the Nominating Committee.

An informal meeting was held Thursday, Sept. 10. Miss Shiras opened the meeting by saying that the outlook for scientific photography was expanding so rapidly that if we are to cover the ground we will have to work together in a more organized way than heretofore. She suggested dividing the members into fields, giving each field a formal or an informal Chairman, and getting the groups to work on problems in their own spheres. There was no argument about the desirability of some such program, but the method of dividing the fields raised a discussion. Would it be better to divide according to sciences (medicine, biology, criminology, etc.) or according to photographic types (motion pictures, photomicrography, etc.)? On the whole it was felt that to divide according to sciences would be more useful. Many of our members are not photographers but scientists, and they are the very members who most often ask for help. It was felt they could most efficiently be served by a committee who understood their scientific problems as well as their photographic needs.

But if we become an organization of special groups, and if the kinds of groups increase, as seems likely — can a small quarterly Journal carry the variety of information needed? The problem is complicated by the fact that we have experienced and inexperienced members and one article can rarely be of use to both. It was agreed that we could not hope to keep all the necessary information running currently in our Journal, and that we needed to amplify other sources of information such as albums, exhibits, booklets, groups of slides, etc. But it was also agreed that because of the overlapping of interest between groups and between kinds of photography, single articles might be adapted for several groups. If, for instance, an article on some technique of medical photography were sent to the group heads, each might be able to add a few comments adapting that technique to the problems arising in their own field. It was also felt that more could be done to review and co-ordinate the material published in the Journal. Abstracts taken from several articles on one subject might form a valuable article in themselves. And references to related articles might be published as bibliographies from time to time.

Exhibitions at future annual meetings of the A.A.A.S. were urged, as these meetings are attended by many scientists who are becoming increasingly interested in photography.

Speaker of the Evening, 1943 — We take pride in announcing that Dr. Peyton Rous was our guest-of-honor at the annual dinner. As most of our readers know, Dr. Rous has done authoritative work in the field of pathology and bacteriology, particularly in tumors due to viruses.

He is a Member of the Rockefeller Institute for Medical Research, and an editor of the Journal of Experimental Medicine. A firm believer in the importance of scientific illustration, he has worked in close collaboration with Mr. Schmidt for many years in the presentation of his medical work. It was at Mr. Schmidt's invitation that he joined us in Princeton.

Dr. Rous not only kept us laughing but he moved us as well, for he presented as convincing a case for scientific photography as most of us had ever heard. His speech was extemporaneous, which made it all the more delightful, but thwarts our very real desire to preserve it in this Journal.

New Directors — The Board of Directors welcomes as one of its members Mr. Nathan Horton, of Ayerst, McKenna and Harrison, Rouses Point, N. Y. Mr. Horton has been our Salon Chairman for several years, and was unanimously elected by the Directors to fill the vacancy left when Mr. John Bledsoe went on overseas service.

At our 1942 Convention, Capt. Ralph P. Creer discussed the Army's plan to illustrate the medical history of World War No. 2. In the meantime, most of these ideas have been put into effect and at our re-

---

Upper photograph

1ST DETACHMENT—MUSEUM AND MEDICAL ARTS SERVICE

Army Medical Museum *(Somewhere in India)*

Standing, left to right: Sgt. R. Smith, Sgt. P. Lund, Pfc. E.. Robinson, Cpl. R. B. Schnick.

Seated, left to right: Lt. C. Graham Eddy, Sgt. F. S. Beal, T/Sgt. L. Binder.

Middle photograph

2ND DETACHMENT—MUSEUM AND MEDICAL ARTS SERVICE

Army Medical Museum *(Somewhere in England)*

Standing, left to right: Pfc. H. E. Lackey, Sgt. J. Nalepovic, Sgt. C. B. Potter, Cpl. H. Francis.

Seated, left to right: T/Sgt. R. C. Adams, Jr., Capt. R. Donald Reed, Sgt. H. L. Cradick.

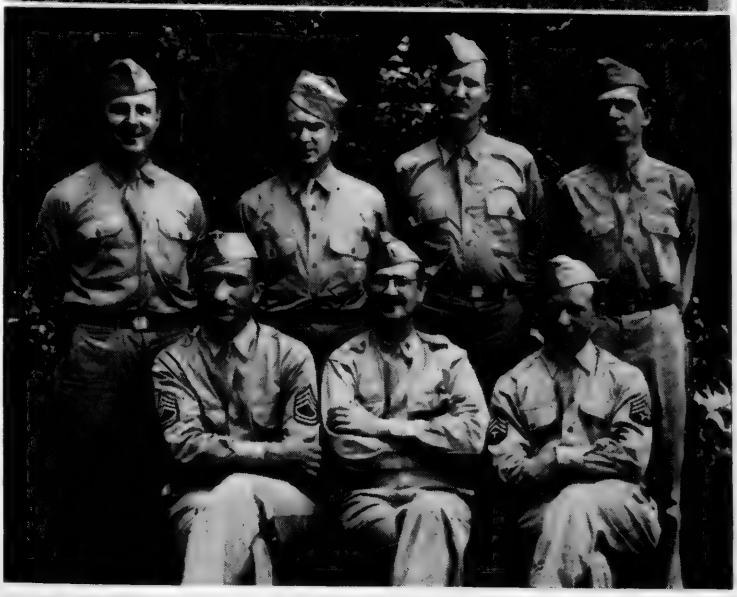
Lower photograph

3RD DETACHMENT—MUSEUM AND MEDICAL ARTS SERVICE

Army Medical Museum *(Somewhere in Africa)*

Standing, left to right: Sgt. M. Manson, Pfc. W. W. Hay, Sgt. H. Goodwin, Cpl. M. Shaffer.

Seated, left to right: T/Sgt. L. Breslow, Capt. Carl D. Clarke, Sgt. P. Showstack.



cent Princeton meeting, Capt. Creer submitted what might be termed a "progress report".

This new organization, the Museum and Medical Arts Service, under the direction of Colonel J. E. Ash, is attached to the Army Medical Museum where the personnel that make up the detachments of the M.A.M.A.S. undergo a training program.

The units consisting of six enlisted men and one officer are attached to the larger medical installations in the various important theaters of operation and are under the direction of the Surgeon of each Theater. All material collected by such units will be shipped to the Museum where it will be available for study and research. To date three units are on duty in the combat zone and a great deal of interesting and valuable illustrative material has been received.

In addition to this illustration service for overseas units, a plan to organize clinical photographic dpartments within the Zone of the Interior is underway. Approximately twenty-two General Hospitals within the continental limits of the United States will be supplied with adequate photographic equipment, supplies and personnel. Copies of all clinical photographs will be sent to the Army Medical Museum for dissemination within the entire Medical Department.

It is planned to centralize all medical photographic activity in the United States Army at the Army Medical Museum so that valuable illustration material (both still and motion pictures) will be readily accessible to all branches of the armed forces.

PROGRAM

Thirteenth Annual Convention

Thursday, September 9

9:00 A.M.	Registration. East Room; Downstairs.
10:00 A.M.	President's Address. Ranger Room. Mr. Ferdinand Harding, Children's Hospital, Boston, Mass.
10:30 A.M.	Illumination Problems with Low Power Magnifications. Mr. Arthur L. Smith, Department of Zoology, Cornell University, Ithaca, N. Y.
11:00 A.M.	The Biology of Reproduction in Rats—A Motion Picture in Kodachrome, with Remarks on Titling, Time Lapse, etc. Dr. Edmond Farris, The Wistar Institute of Anatomy and Biology, Philadelphia, Pa.
11:30 A.M.	Business meeting. Places of Interest about Princeton.

RECESS FOR LUNCHEON

1:30 P.M. Anesthetizing Laboratory Animals for Photographic Purposes.
Mr. Howard Kothe, the Fleischmann Laboratories,
New York, N. Y.

2:10 P.M. Trip to: RCA Laboratories. Demonstration of New Small Electron Microscope. A Birth Certificate or Proof of Citizenship is necessary for admittance to the Laboratories.

3:10 P.M. Starting from the RCA Laboratories to: The Rockefeller Institute for Medical Research, Department of Animal and Plant Pathology.

7:45 P.M. Meeting. For the Good of the Association and its Members.

Friday, September 10

9:30 A.M. Photographic Advances of Interest to Biological Photographers. Ansco Color Film and Ansco Color Paper. A Description of the Ansco-Sweet Photoelectric Densitometer.
Mr. Lloyd Varden, Agfa Ansco, Binghampton, N. Y.

9:50 A.M. Fluorescence Photomicrography.
Dr. E. Loewenstein, Bausch & Lomb Optical Company,
Rochester, N. Y.

10:30 A.M. The New Defender Pan-Chroma Process. A Method of Making Color Prints Directly from Kodachrome.
Mr. Leonard Perskie, Defender Photo Supply Company,
Rochester, N. Y.

11:00 A.M. Medical Illustration Goes to War.
Capt. Ralph Creer, SNC-AUS, Army Medical Museum,
Washington, D. C.

11:45 A.M. Election of Officers.

RECESS FOR LUNCHEON

2:00 P.M. The Use of Films at the National Naval Academy, An Informal Description of Teaching Methods in the Navy.
Lieut. Warren Sturgis, Naval Medical Center, Bethesda, Md.

2:30 P.M. Intra-Oral Kodachrome Photography.
John W. Richter, D.D.S., New York, N. Y.

3:05 P.M. "Unseen Worlds".—A Motion Picture with Sound.
Dr. James Hillier, Radio Corporation of America,
Princeton, N. J.

3:35 P.M. What I Want in Post-War Equipment. A Round-Table Discussion
Photographers and Firm Representatives.

7:30 P.M. Annual Banquet. Ranger Room.

After the Banquet "Venezuelan Jungle Life." Kodachrome Motion Pictures
Miss Jocelyn Crane, New York Zoological Society,
New York, N. Y.

Saturday, September 12

9:30 A.M. The Demonstration of Magnification and Resolution by Photomicrography.
Dr. Oscar Richards, Spencer Lens Company, Buffalo, N. Y.

10:10 A.M. Making Black-and-White Prints from Kodachrome Transparencies.
Mr. H. L. Gibson, Eastman Kodak Company, Rochester, N. Y.

10:30 A.M. Some Experiences in the Preparation of Microfilm.
Mr. Stanley McComb, Mayo Clinic, Rochester, Minn.

10:50 A.M. The Use of Miniature Flash Bulbs in Clinical Photography.
Capt. Ralph Creer, SNC-AUS, Army Medical Museum, Washington, D. C.; and Mr. Norman Lipton, General Electric Company, New York, N. Y.

11:15 A.M. What a Medical Student Looks for in a Teaching Film and How These Points were Obtained by a Medical Student Photographer. Kodachrome Motion Pictures.
Robert Mallory III, M.D., Philadelphia, Pa.

The Association extends its thanks to the firms participating in this Convention for their steadfast support. The following firms were represented in the Technical Exhibits:

Agfa Ansco	Radio Corporation of America
Clay-Adams Co., Inc.	Douglas Winnek
Eastman Kodak Company	Defender Photo Supply Co.

1943 SALON REPORT

This report could, if one desired, be the soul of brevity consisting of the following wording: number of exhibitors—12; number of prints hung—71.

Although this is rather a feeble showing compared to what we had optimistically hoped to get, nevertheless one must take into consideration that times are not what they used to be. This writer, however, is still somewhat obstinate in his belief that for an organization the size of the BPA we are getting a very poor showing in our annual salon. Maybe it is our approach that is wrong; possibly the advance publicity is either too lurid or too weak; maybe the people are just too busy to tackle the tremendous job of making four or five prints for the BPA once a year. Whatever the cause, we still have a long way to go in developing a truly representative salon . . . a salon which gives the viewer a pictorial cross-section of scientific photographs. However, the war can't last forever, and we are going to continue to live in hopes.

As regards the factual data, other than that at the beginning of this report, we might say that photomicrographs still lead the field—18

were exhibited. The balance of pictures comprised an infinite variety of subject matter. We must admit that the technical excellence was as good, if not better, than in former years. The entry forms were a definite aid in the checking and recording of the salon data, and next year we plan on getting these out well in advance of the salon.

Transparencies were up to the average standard set in former years, and were well displayed.

N. S. Horton, Salon Chairman
Montreal, Canada

MEETING IN LONDON OF THE ASSOCIATION FOR SCIENTIFIC PHOTOGRAPHY

The British counterpart of the B.P.A. approaches scientific photography from a different angle than ours. It was formed for those who apply or might apply photographic techniques to their work, rather than for photographers who are interested in the application of their work to scientific problems. We assume that it will be composed less of practising photographers than of research workers in science, industry and photography.

The first meeting was held at the Royal Institution on July 5th. The President, Prof. J. Yule Bogue, Ph.D., M.R.C.V.S., made some introductory remarks on the purposes and possibilities of the organization. He said that it would be to the mutual advantage of workers from widely different fields to be brought together, for they would discuss not only their photographic problems, but also their particular lines of investigation. He then mentioned some of the application of photography to technical or scientific problems; studies in the refractive index of the atmosphere by the Schlieren photographic method; photo-elastic analyses; photomicrography for the study of structures; mass radiography and kinematographic analyses.

Other speakers presented papers on: "Indirect Radiography as Applied to Medical Work"; "Some Miscellaneous Applications of Industrial Photography"; "Substandard Kine-Photomicrography"; and "The Photography of Photo-Elastic Stress Patterns".

A meeting was scheduled to be held in September at the Middlesex Hospital on the clinical photography of patients. The announcement stated that "if sufficient interest is evident among members, it is pro-

posed to form a group to discuss medical photography more frequently than will be possible in the monthly series of meetings which has to do with the whole field of science."

Subjects scheduled for the next few general meetings are: Photographic templates, electrical engineering, and a joint exhibition of apparatus with the Scientific and Technical Group of the Royal Photographic Society.

We are indebted to the Association's Secretary, Mr. R. McV. Weston, for information about these meetings, and for a copy of an article on the first meeting reprinted from Nature, Vol. 151, p. 718, June 26, 1943. The headquarters of the Association are at Tavistock House North (1st floor), Tavistock Square, London, W.C. 1.

B.P.A. Officers and Committee Chairmen

President	Ferdinand Harding The Children's Hospital Boston, Mass.
Vice President	Henry W. Morris University of Minnesota Minneapolis, Minn.
Secretary	Anne Shiras University Office Magee Hospital Pittsburgh, Pa.
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Committee for Cooperation with the Army	Capt. Ralph P. Creer Army Medical Museum Washington, D. C.

Committee for Cooperation with the Navy	Ferdinand R. Harding The Children's Hospital Boston, Mass.
Traveling Salons	Louis Schmidt Rockefeller Institute New York, N. Y.
Salon Chairman	Nathan S. Horton 1005 McGill Building Montreal, Canada
Editor of Journal	Leo Massopust Marquette University Milwaukee, Wisconsin

SUSTAINING MEMBERS

Some individuals who have a deep interest in the advance of scientific photography help finance a wider range of activities for the Association by becoming Sustaining Members. The privileges of Regular and Sustaining members are the same. Either type may be chosen each July when the dues are payable.

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THE JOURNAL OF THE BIOLOGICAL PHOTOGRAPHIC ASSOCIATION

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Manuscripts should be sent to Leo C. Massopust, Editor, Marquette University School of Medicine, Milwaukee 3, Wisconsin. They should be typed and double spaced; only the original copy should be *submitted.* Original drawings not photographs of drawings should accompany manuscript. All illustrations should be marked with the author's name and address. General references to literature should appear at the end of the manuscript. References to literature cited should appear as footnotes.

All articles published in this JOURNAL must be contributed to it exclusively. If subsequently printed elsewhere, due credit must be given as to the source of original publication.

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All matters concerning the Association should be sent to Miss Anne Shiras, Secretary, University Office, Magee Hospital, Pittsburgh 13, Pa.

Correspondence concerning subscriptions and other business matters should be sent to Leo C. Massopust, Editor, Marquette University School of Medicine, Milwaukee 3, Wisconsin.

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EDITOR

For the advancement of photography in relation to the biological sciences.

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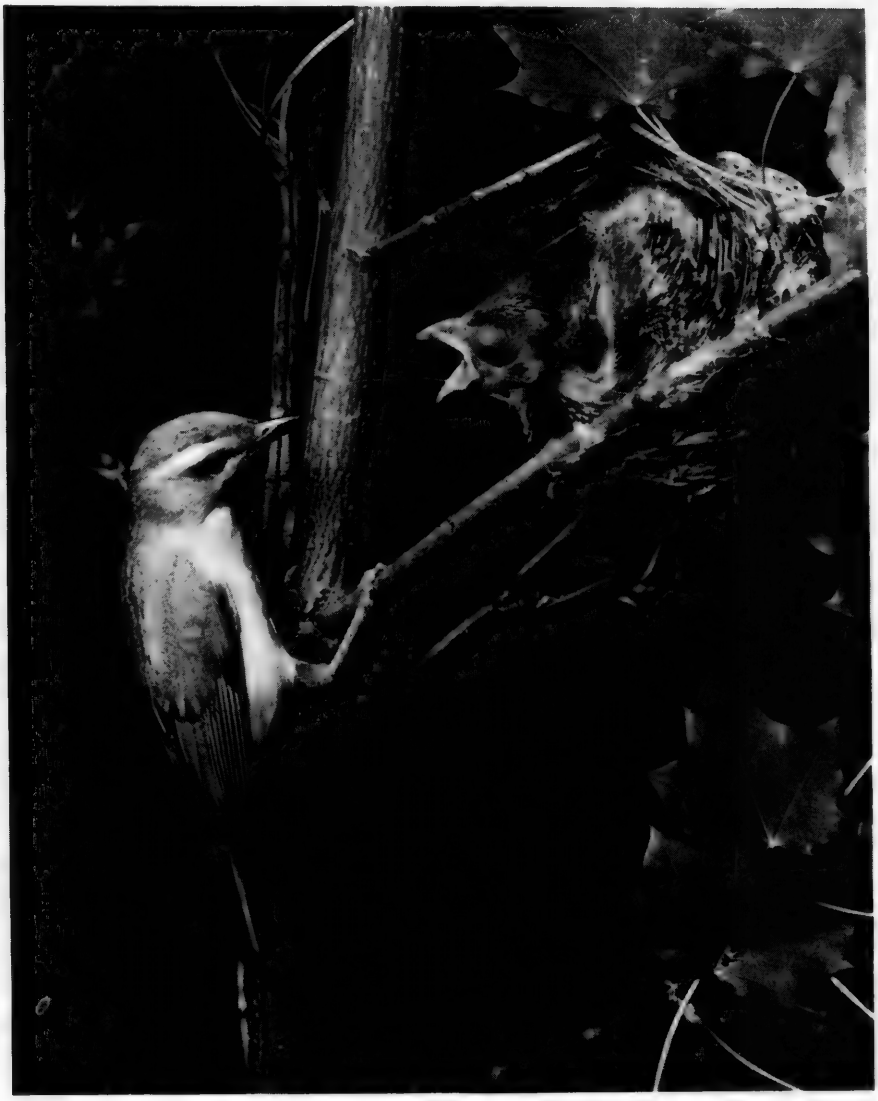

RED-EYED VIREO WITH YOUNG COW BIRD IN NEST

Photographed by Eliot Porter, M.D., Hubbard Woods, Illinois, 1941, using a 9 x 12 cm. Linhof equipped with an 18.5 cm. focal length Zeiss Protar lens in a Compur shutter. Two G. E. No. 21B flash lamps in 11 inch, aluminum, Victor reflectors are placed, one on either side of the camera, with their rims 18 to 20 inches from the subject. The lamps are ignited by a 45 volt radio battery. The circuit is closed by the operation of a Kalart Micromatic synchronizer. The exposure is 1/200 second with an 8 mm. aperture for Daylight Type Kodachrome.

Illumination Problems with Low Power Magnifications . . . A Summary of Methods

by Arthur L. Smith*

THE photography of biological specimens under low power magnifications often involves conditions differing from those of conventional photomicrography. Usually referred to as photomacrography or macrophotography, the field includes magnifications which for the purposes of the present discussion will be from X2 to X20. Specimens within this range may be translucent, opaque, or a combination of both, and the choice of a method of illumination will thus depend on the nature of the specimen. A summary of methods, as shown in figure one, demonstrates some of the possible technics and combinations which may be used.

The problem of illuminating tiny objects is, in many cases, similar to that of lighting large specimens. Surface, size, shape, and translucency vary to such an extent that each one may often be considered as a separate problem. Recording the characteristics of an opaque object, for example, may require a spotlight for the basic light source and shadow lights for secondary sources, as in the case of larger specimens. The inefficiency and inaccessibility of the larger lighting equipment for such work is obvious, and it becomes necessary to use lighting units which will direct small but brilliant areas of light as required. The desirability of using small lighting apparatus is, however, hampered by the fact that much of it utilizes lamps which cannot produce a sufficient intensity of light to permit accurate focusing on a ground glass. The reason for this is that most miniature lighting apparatus is intended for visual rather than photographic work. There are two answers to this problem. One is to use only the lamps which do permit sufficient brilliancy. The other is to have at least one brilliant lamp which can be used for focusing and then either be omitted from the general light-

* From Photographic Science Service, Cornell University, Ithaca, New York. Received for publication August 11, 1943. Submitted while on the Staff of the Zoology Dept.

The author would like to acknowledge assistance by the E. Leitz Corp. of New York, Bausch & Lomb, Rochester, N. Y., and the Zoology Department of Cornell University in making it possible to reproduce part of the plates in this paper.

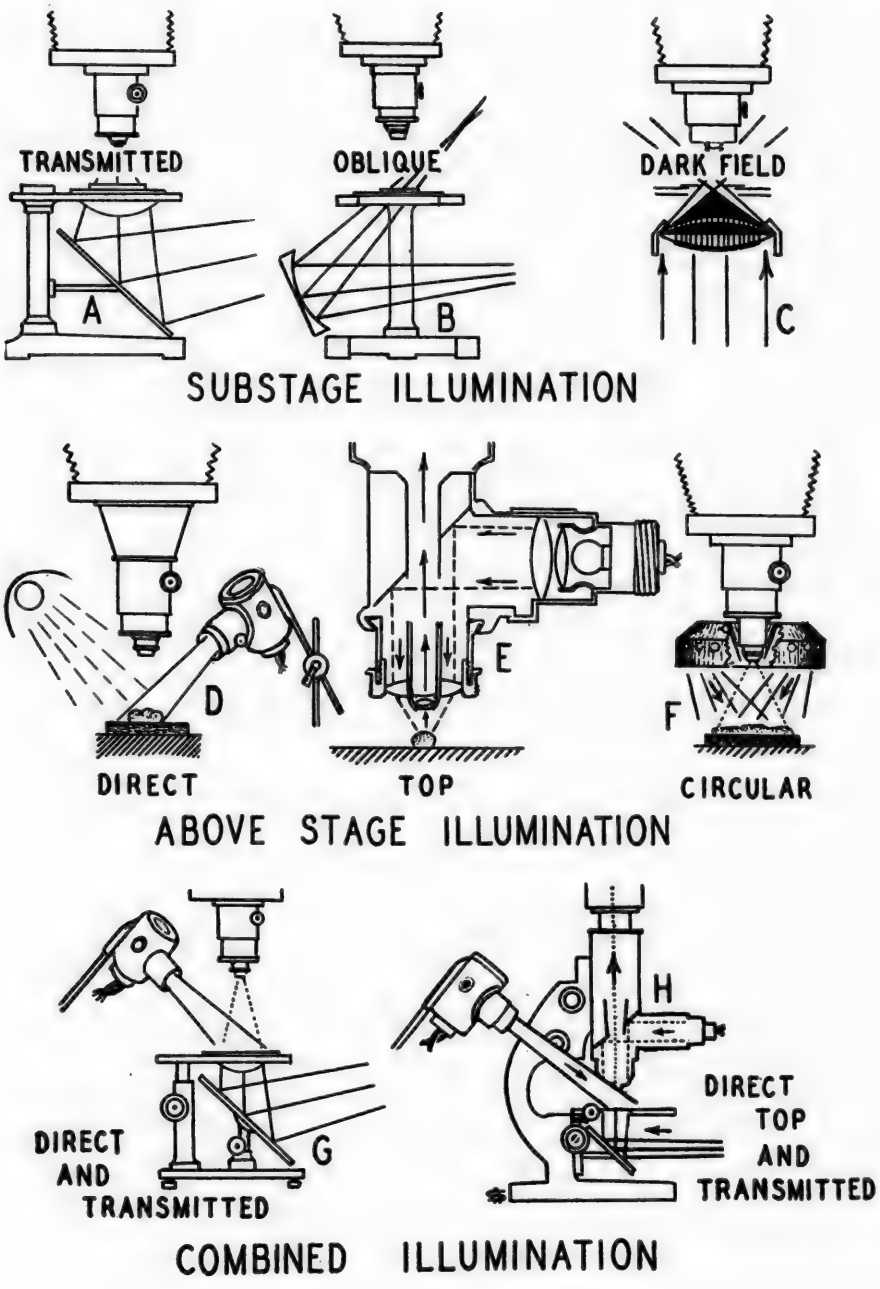

Figure 1. A summary of low power lighting methods.

ing arrangement or reduced in intensity to match the other less brilliant lamps being used. Many other problems may also be encountered, such as the movement of living specimens, highlights on glossy specimens, or instances where the area to be photographed is part of a large unwieldy specimen. Throughout the process it will be noticed that problems of illumination provide the most interesting considerations, since light is a factor which must be controlled by the individual, thus demanding art, skill, and ingenuity. The requirements of scientific photography coupled with the limitations of the photographic process necessitates a good knowledge of lighting, sensitized materials and practical optics.

Substage Lighting

Transmitted

Transmitted substage lighting, as applied to low power magnifications, cannot be obtained satisfactorily from standard microscope condensers since the size of the specimen often exceeds the useful area of light. Divisible substage condensers permit some increase from non-divisible types, but in general it is necessary to use those which have been specifically designed to permit large coverage. Typical of these are the Bausch and Lomb macro-condensers which are used with matching Micro-Tessar objectives having focal lengths of 32 mm., 48 mm., and 72 mm. Even the largest of these condensers, however, is not suf-

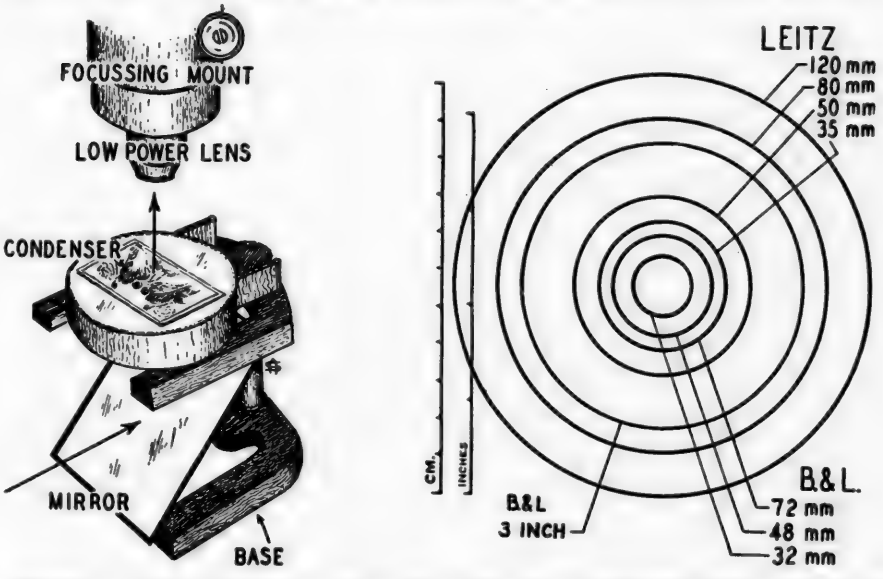

Figure 2. Leitz low power stage with 120 mm. condenser (left). Circles on right indicate relative size of present power condensers.

ficient for many specimens since it has a useful maximum diameter of about one and a quarter inches. The exception is with their Photographic Microscope which has a three inch condenser for low power work. The Leitz series of macro-condensers will accommodate sizes from one and a quarter inches to four and a quarter inches in diameter.

In addition to the large condenser requirements for substage transmitted light there is also the need for larger light sources and special

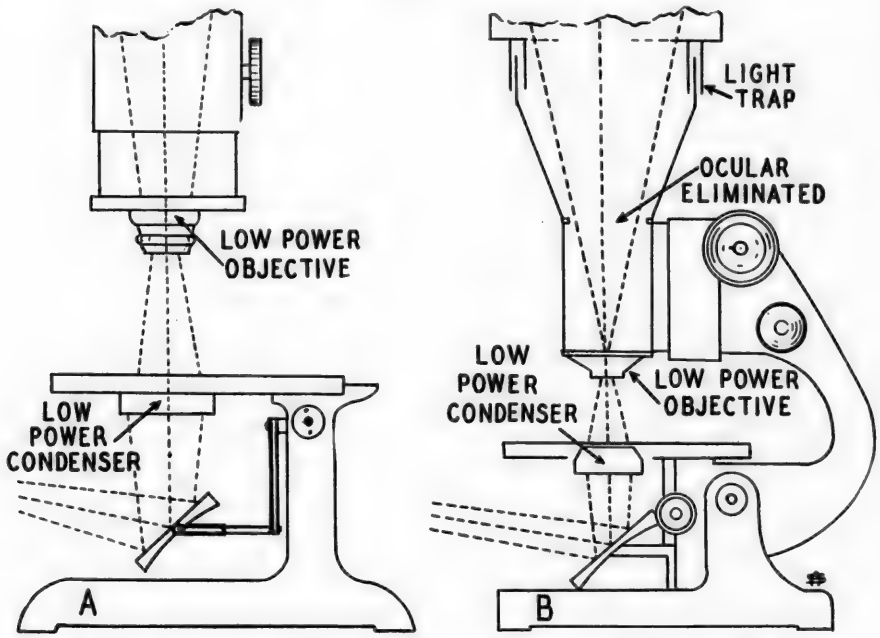

Figure 3. (A) Bausch and Lomb low power stage. (B) Microscope in which a low power condenser has replaced the standard condenser and a funnel shaped light trap is attached to the top of a wide body tube, eliminating the ocular.

low power stages to replace the microscope when the magnification is too low for its use. Both Bausch and Lomb and Leitz can supply stages for use with their condensers, but they lack the flexibility which is so needed. A low power stage such as that devised by the author[1], see figure 4, comes much closer to permitting flexibility than any of those commercially made. When large substage condensers and stages are not available or the specimen is too large for such equipment, an opal glass illuminated evenly from below may be satisfactory.

[1]A Flexible low power stage. A. L. Smith, J. of B. P. A., Vol XI, No. 4; p. 171, June, 1943.

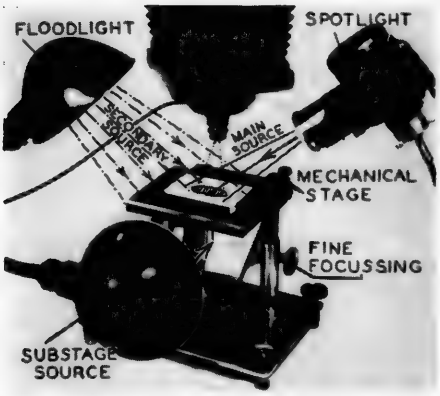

Figure 4. Low power stage designed by author and showing how ordinary desk lamps with parabolic reflectors can be employed as secondary light sources.

Sources of even illumination which are sufficiently large to fill a four inch macro-condenser or to illuminate an ever larger opal glass are difficult to secure. This is particularly true if the source must conform to certain dimensions to fit an individual apparatus set-up. The answer to the problem, in many cases, becomes one of adaptation or construction. Most microscope lamps are limited in the field which they can cover and for this reason flood lamps in reflectors producing diffuse light, and having provisions against hot spots, have been found most satisfactory as large sources. Due to the necessary size and brilliancy of such sources the problem of heat is usually encountered. Air cooling or heat filtering methods can be adapted for such control.

Oblique Substage Illumination

Oblique substage illumination is customarily secured by a substage mirror which is outside of the angle of image inclusion. A concentrated light source is focused upon the mirror, which in turn is directed toward the subject. The effect is to produce a directional illumination wherein parts of the object become visible either because they are translucent and scatter light towards the objectives or by direct reflection. In photomacrographic practice oblique substage illumination is most useful as a secondary source of light combined with top illumination. This will be illustrated further in this paper.

Dark Field

Dark field illumination differs from normal oblique illumination by producing a circular field of oblique rays which are concentrated evenly at the area where the subject lies. The dark field effect, as normally used in photomicrography, is secured by either a special condenser, see figure 5a, or by means of a dark field stop in which the quality of the effect is not quite as efficient. The difficulty encountered with low power magnifications is that the objects exceed the size

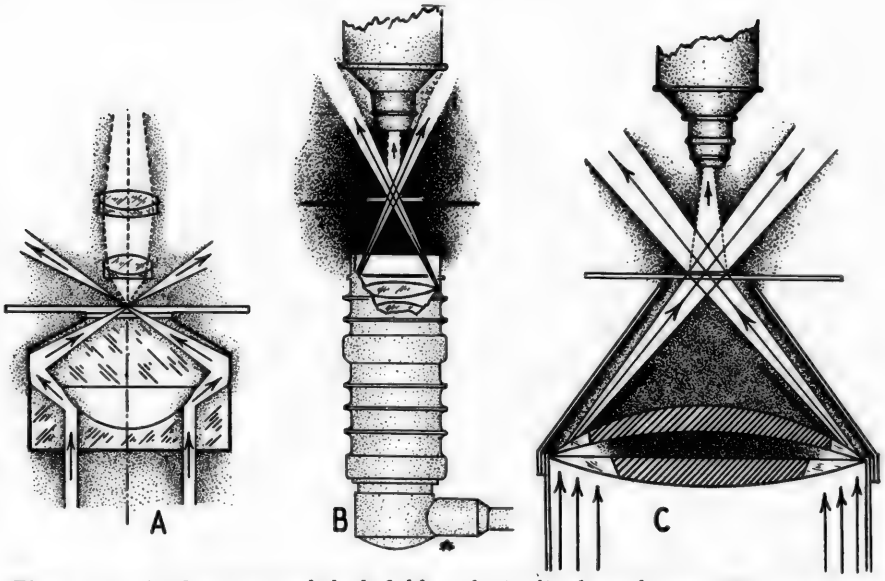

Figure 5. (A) Conventional dark field with Cardioid condenser. (B) Low power dark field method suggested by Dr. Richards. (C) Arrangement for low power dark field as used by author.

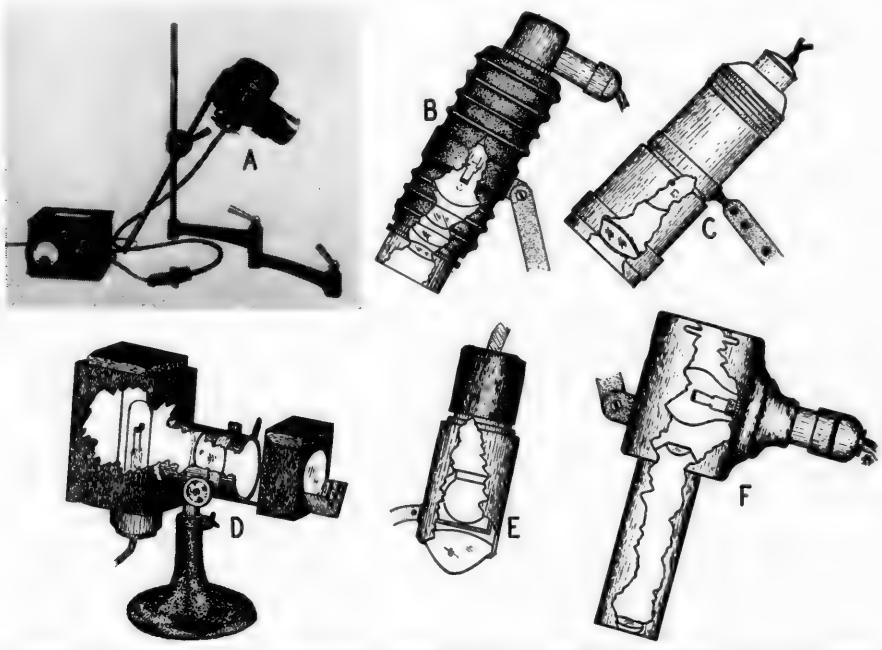

Figure 6. Some of the spotlights which can be used effectively in low power work. (A) Leitz spotlamp with transformer-rheostat. (B) Spencer Universal Lamp. (C) Leitz Mignon lamp. (D) Bausch and Lomb standard ribbon filament lamp with water cell and filter holder attached. (E) Zeiss Epi-lamp with aspheric lens. (F) Bausch and Lomb Nicholas Illuminator producing a parallel beam.

limitations of the normal dark field condenser, which is intended only for medium and high powers. The solution to low power dark field seems to be in the use of laboratory constructed arrangements which utilize a large dark field stop in front of a spotlight[1], figure 5b, or an apparatus as used by the author, figure 5c, in which large condensing lenses are employed.

The dark field effect depends considerably on the nature of the specimens since only certain objects demonstrate desirable characteristics with this type of illumination. Soft tissues, in most cases, are not so pronounceably displayed as hard chitinous materials such as fish scales.

Above Stage Illumination

Methods of above stage illumination are numerous, and each one has its particular advantage. For purposes of explanation they can be grouped into three classes, (1) Direct, (2) Top, (3) Circular.

Direct Illumination

The use of direct sources for main lighting with secondary shadow lights to maintain detail in shadow regions parallels the standard technics employed in general photography. The requirements are to demonstrate shape, size, depth, and structure. To indicate the general shape, the specimen must be outlined against a contrasting background. Size may be shown by including a measuring scale, or some other comparison device, in the scene. The depth and structure effects are secured by the quality of the lighting. A main source of brilliant light, such as a spotlight, augmented

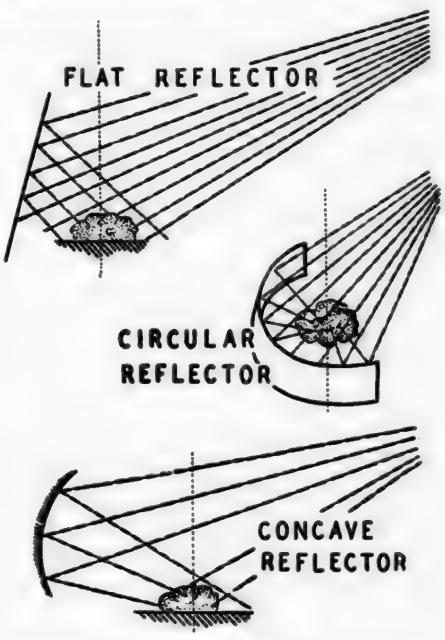

Figure 7. Flat reflector for standard use instead of, or augmenting secondary source; Circular reflector which fills in a greater amount of shadows than the flat reflector; and Concave reflector which brings reflected rays to a concentrated point, thus very often becoming the main source.

[1]Photomicrographic Notes. Dr. O. W. Richards, J. of B.P.A. Vol X, No. 3; March, 1943, p. 109.

by secondary light, will produce good form and still permit necessary detail in shadow areas. As substitutes for secondary sources, reflectors have been found quite satisfactory, figure 7.

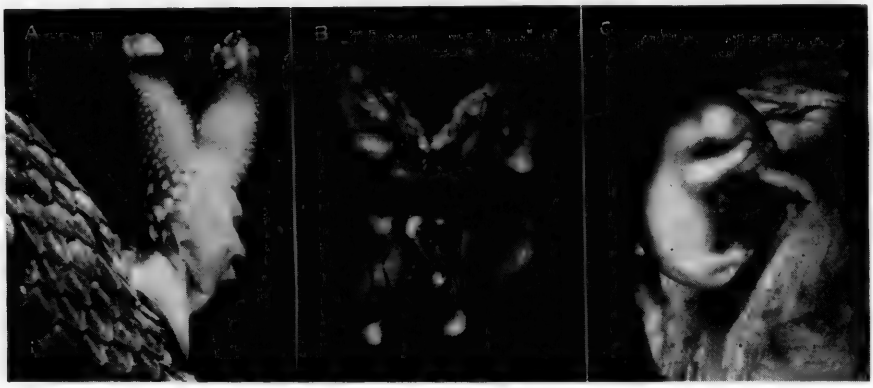

Figure 8. Examples of subjects photographed with direct illumination. (A) Right hemipenis of Natrix barteri Trapido, everted, showing flat lighting from single source in which the subject does not require extremely careful modeling. (Original photograph X4). (B) Male reproductive tract of a field mouse showing careful modeling as a result of using a main spot source, a diffuse secondary source, and two small flat reflectors. (Original photograph X3.5). (C) Young opossum Didelphis virginiana attached to nipple, showing a small amount of modeling, just sufficient to suggest form but without blending into dark shadows. A spotlight and one secondary source was used. (Original photograph X5).

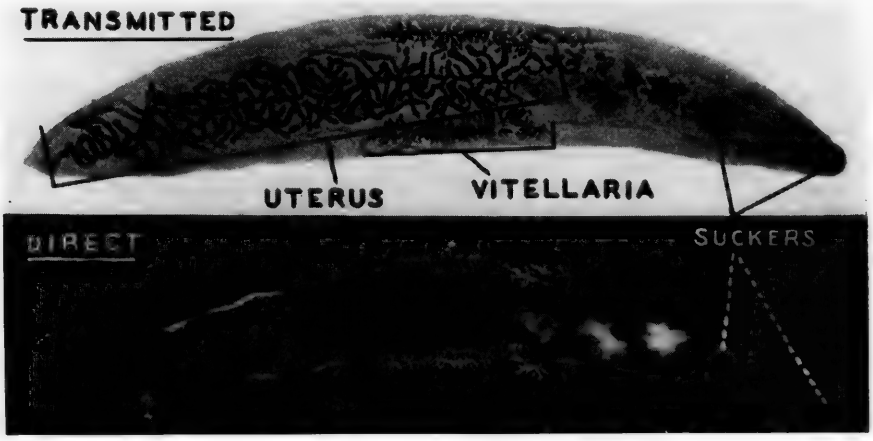

Figure 9. Lancet liver fluke, Dicrocoelium dendriticum photographed from same position by transmitted and direct lighting.

In considering the nature of the subject, there are two principal surfaces which are encountered. One is the irregular surface with which the depth illusion can be recorded by the proper balancing of a fairly flat illumination, the various protuberances and depressions aiding in the depiction of form. The other type of surface is a smooth curved one which will require modeling. Highlights blending gradually into shadows can be accomplished by careful use of reflectors, and secondary lights in relation to the primary source.

Direct lighting is also used on flat plane specimens where an even flat illumination is required and which may be obtained by a single even beam or by equi-balanced lighting. Direct illumination, as presently defined, is the most common method of above stage illumination. The extreme variations in type, position, direction, and brilliancy of light sources makes possible innumerable lighting combinations. The selection of such combinations is thus seen to be dependent upon varying factors. The choice of a single illumination for a certain object is not always sufficient, however, for there are times when two or more types are required. For example, the liver flukes shown in figure 9 demonstrate considerably different characteristics with transmitted light than they do with direct incident light. There are many such instances where two photographs are necessary to record the correct impression of a specimen.

A mechanical difficulty sometimes encountered with direct illumination is with the use of certain lamps and angles of illumination when

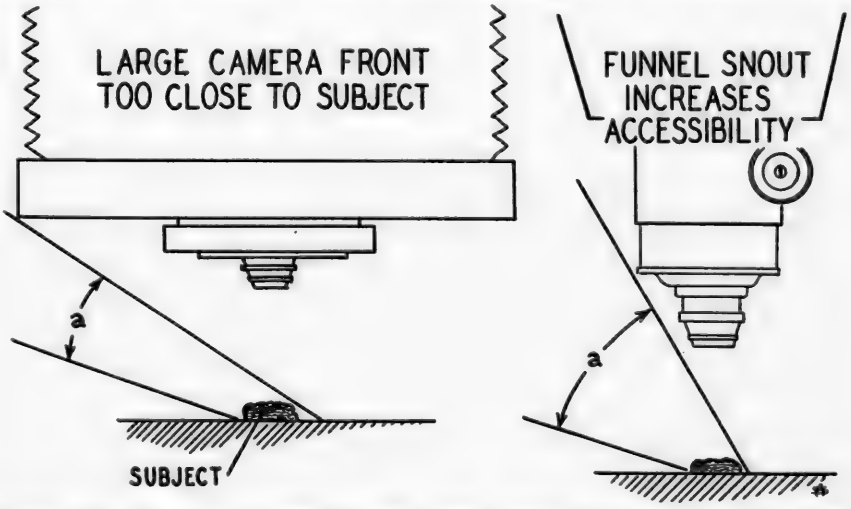

Figure 10. By using a funnel shaped snout attached to lens board, the angle of lighting accessibility is greatly increased.

the camera front is too wide and too close to the subject. By using a funneling snout in the camera lens board, a considerable increase in the angle of illumination is made possible. This is shown in figure 10.

Top Illumination

There are two principal methods of top illumination and these are shown in figure 11. Top illumination is obtainable only with special equipment since the objective and the source are in the same place. Its use is not limited to the magnifications considered in this paper, but it does include them. *Vertical Illumination* is most commonly used for photographing flat surfaces, as in metallography, and by its nature does not produce shadows. A sharp flat image showing the structure of the specimen may be produced. This type of lighting is often called bright field incident illumination and differs from figure 11b in which the light strikes the subject at an angle and the field is dark. *Incident dark field illumination* is represented by equipment such as the Leitz Ultropak, figures 4, 12, 15. Valuable features of the Ultropak are the low power immersion objectives, one of which was used to photograph figure 13, and the sector diaphragm by which the circular field of illumination can be reduced to directional lighting. Polarizing equipment can also be employed.

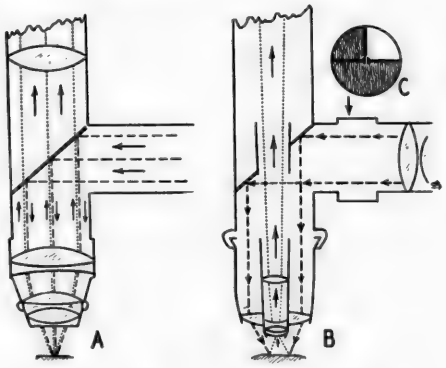

Figure 11. Two principles of top illumination. (A) A semi-transparent reflector directs light down through the actual objective, producing a bright field. (B) The outer area of an opaque mirror reflects light down through the outside of the objective where it is directed by a built in condenser to the subject. Light reflected from the subject passes up through the objective the magnifying optics of which are located in the center of the mount. A dark field effect is obtained. (C) Sector Diaphragm.

Circular Illuminants

The apparatus which, for the purpose of designation, can be called circular, illuminates a specimen from all sides and usually from a much lower angle than the Ultropak. The effect is a flat even illumination, casting shadows which are largely balanced by light from other direc-

tions. In many instances photographs using this type of illumination have very little of the character and illusion of depth that can be produced by direct illumination with a main primary source of light. The four devices shown in figure 14 are examples of commercially available circular illuminators. Three of these, the Leitz Macro and Micro Ring Illuminators and the Bausch and Lomb Surface Illuminator depend upon a ring of lamps, while the Zeiss Epi-Mirror has a single source which is reflected by a curved annular mirror.

Combined Illuminants

Probably the most interesting of all the problems in photomacrography is the use of combined illuminants to produce precise and exact lighting effects. A commonly used combination is one in which the subject is illuminated by direct

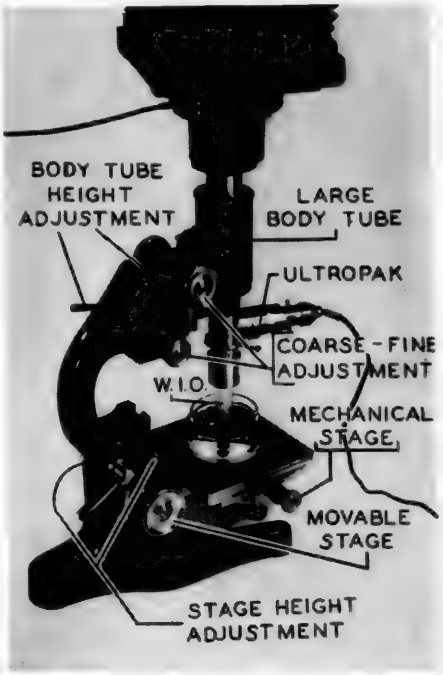

Figure 12. The Leitz Ultropak shown on an extremely flexible Leitz microscope. Note the low power water immersion objective (W.I.O.) which was used to photograph both A and B in figure 13.

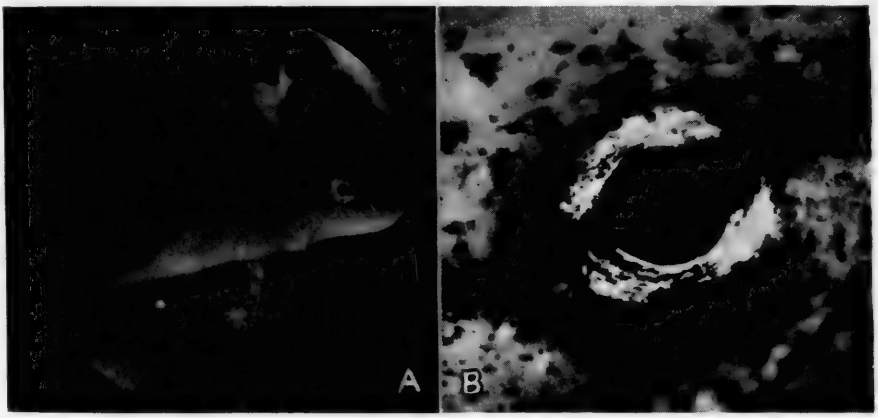

Figure 13. Photographs made with Leitz Ultropak lighting accentuated by a low angle spotlight. (A) Salamander in egg. (B) Eye of anaesthetized salamander.

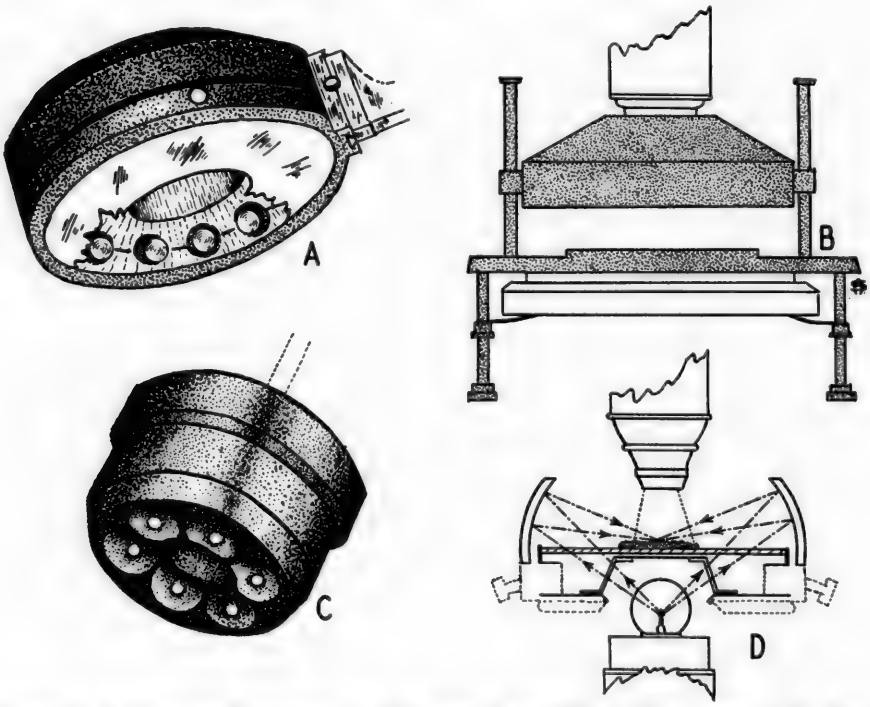

Figure 14. Circular illuminants. (A) Leitz Macro Ring Illuminator. (B) Leitz Micro Ring Illuminator. (C) Bausch and Lomb Surface Illuminator. (D) Zeiss Epi-condenser.

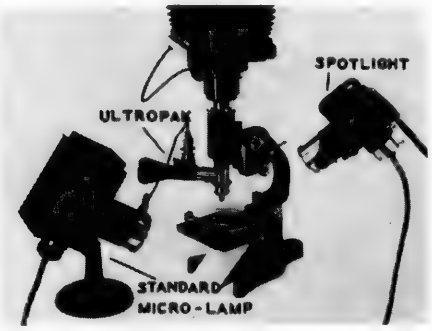

Figure 15. A combination set-up employing direct spotlighting, top lighting with the Ultropak, and substage lighting with a standard microscope lamp.

incident light with a white background obtained by substage lighting. The many variations of combined illuminants are used according to the demands of the particular problem. For example, top illumination accentuated by a direct light at a 35 degree angle and some transmitted substage light was used to photograph figure 13.

Combined oblique illumination is another technic which is easily arranged. Direct incident illumination can be used

as a general source while oblique rays from a curved substage mirror will serve to accentuate certain areas from below, figure 16.

When the specimen is largely translucent, the main source of light may be that which is transmitted. To add a greater quality of depth,

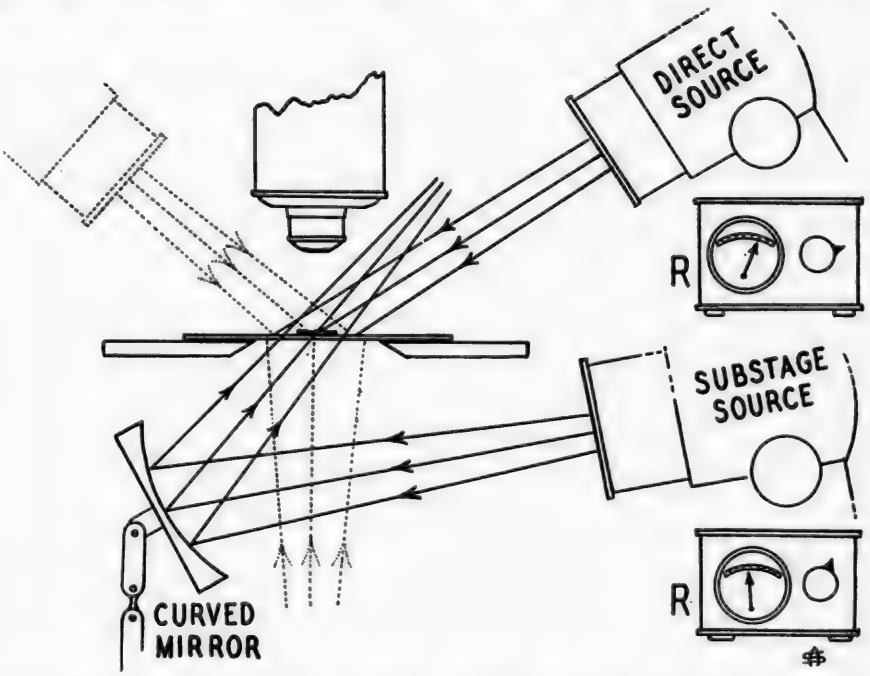

Figure 16. Diagram showing combined substage and above stage oblique illumination. Dotted lines indicate possible additional lighting. The rheostats, designed as "R" are an essential part of the set-up since they permit careful balancing of the different sources employed.

a spotlight can often be used from above to accentuate certain points of the subject.

When several different light sources are used in a single set-up they must be carefully balanced for brilliance. There are several ways by which this can be done, the most satisfactory being the use of continuous control rheostats. Another technic would utilize absorption screens, and a further method would involve moving the source nearer or farther away. The question might logically arise concerning the color quality of illuminants burning at various intensities when using rheostats, but in the experience of the author there have been no indications of bad off-color effects with Kodachrome during four years

of using such a method. A further advantage of light volume control is that in cases where intense heat is quite undesirable the entire lighting set-up can be dimmed except for the times of focusing and exposure.

DISCUSSION

The purpose of this paper has necessarily been limited to a summary since a complete description of details would entail too voluminous a report. It has been the experience of the author that there are a great many factors involved in photomacrography which cannot be generalized since they are dependent upon the types of equipment which are being employed. Those biological photographers who are resourceful and understanding of the relationship of light to the limitations of film are the most successful. In most cases it is also true that the type of specimens submitted in any one laboratory for low power photography are often of a similar nature and this permits the photographer to develop specific technics which may be perfected to conform to the needs of such work. For example, the low power stage designed by the author, figure 4, was primarily made to accommodate large human brain sections measuring 2 x 3 inches. The large dark field condenser, figure 5c, was first used with fish scales, and the arrangement shown in figure 15 was worked out specifically for amphibian eggs.

All the methods shown herein have involved a vertical rather than horizontal apparatus. Whereas in using micro slides in high power photomicrography it seldom matters which way the equipment is used, in low power work it is often very difficult to tip a specimen up on its side, particularly when it must be photographed in a solution. For this reason vertical equipment has proved to be easiest to use. Should it be desirable to photograph a tiny specimen at an angle a camera can usually be set up to face the surface concerned. An example of this, using a miniature camera, is shown in figure 17.

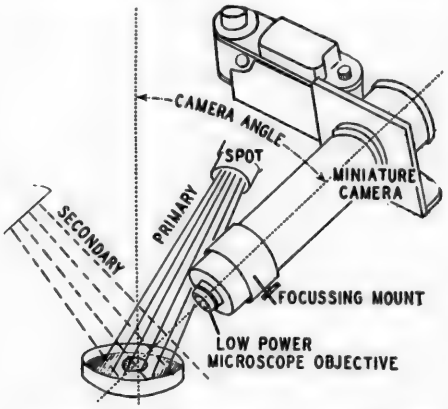

Figure 17. Diagram showing Leica camera set at an angle to make a low power photograph of a subject which cannot be tilted. Lighting shown is not necessarily intended as typical.

As a field, low power photomacrography is rather poorly provided with presently available professional apparatus. It

has been quite evident from the equipment considered in this paper that many of the best instruments are of foreign make, and are thus unobtainable. Regardless of this fact there are large amounts of such apparatus now in use in this country, and it is undoubtedly true that much of it is in the hands of individuals who are not sufficiently aware of its proper use. In one sense, the shortage of equipment will prove of value since it will give the photographer a chance to more carefully evaluate his present equipment and to formulate ideas concerning the nature of desirable post-war apparatus. It will also be surprising what normal ingenuity can accomplish as a substitute for the more elaborate equipment. As a matter of fact, there are actually a great many conditions that necessitate originality in lighting methods. The methods of the photographic process are thus seen to be built up around the requirements of certain problems and as long as new subject problems continue to be submitted, so will the photographer have to devise technics to handle them.

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Reducing Backs for Cameras

by Robert A. Sage*

REDUCING backs are widely used by portrait and commercial photographers and have several advantages for biological photographers at the present time. The principal advantage is greater economy of film. Another advantage is convenience; the versatility of any camera is increased. When a particular film in the desired size is difficult to obtain, a larger film of the same kind may be cut to size in the dark room, and used in a reducing back.

The multiplying back permits two or more exposures on a single film. Backs of this type, as well as the reducing backs described in this paper are built commercially, but are rather difficult to obtain at present and some of them are expensive. The backs described were built or adapted from backs already on hand using ordinary tools and scrap lumber of good quality.

The adaptation of an 8 x 10 inch camera back to accept 5 x 7 film is shown in figure 1. The original back in this case was used on an old Zeiss horizontal photomicrographic camera, and this alteration was necessary to permit the use of standard 5 x 7 plate or film holders. In figure 2, the Eastman Lantern Slide back, used with the Clinical Camera, is shown adapted to the Zeiss 8 x 10 camera back. This back permits the use of Professional Kodachrome in the 3¼ x 4¼ inch size. Graphic type film holders are used. A slight alteration in the width of the lantern slide back is necessary, and this may be done with a chisel or pocket knife. The Lantern Slide plate holders were altered to accept 3¼ x 4¼ inch panchromatic plates, which also involves a small amount of work with a pocket knife. The back is shown assembled in figure 3. It may be removed and used on the Clinical Camera at any time.

Kodachrome film in the 35 mm. size, and more particularly in the 8 exposure Bantam size, is convenient for biological photography. The advantages have been emphasized by Payne.[1] The Eastman Bantam

*From the Photographic Division, Medical Branch, University of Texas, Galveston, Texas. Received for publication July, 1943.

[1] Payne, W. F., "Clinical Photographs in Kodachrome," J. Biol. Phot. Ass'n. Vol. 12, No. 1, pp. 26-34, Sept., 1943.

Kodachrome Adapter, which fits 9 x 12cm. cameras, was used. Figure 4 shows its adaptation to the Zeiss 8 x 10 inch camera back. Only four screws are necessary. The Bantam back slides into small L-shaped

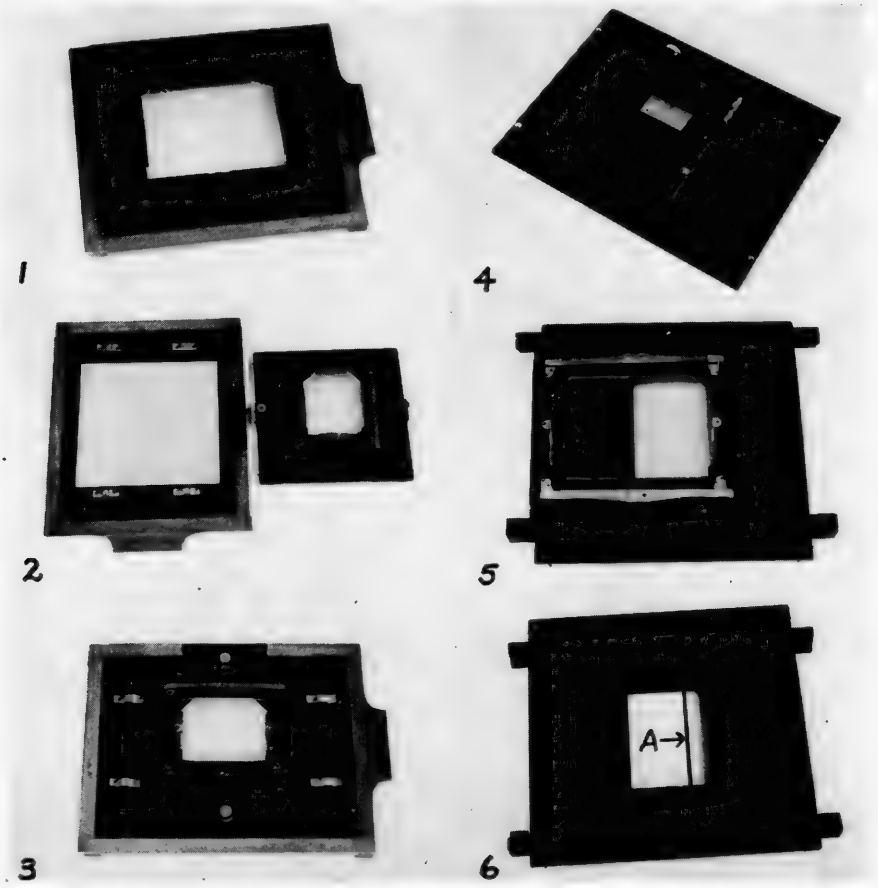


Figure 1. 5 x 7 Eastman camera back attached to Zeiss 8 x 10 photomicrographic back.

Figure 2. Eastman Lantern Slide back with 8 x 10 Zeiss camera back adapted to hold the Lantern Slide back.

Figure 3. Parts of figure 2 assembled and ready for use.

Figure 4. Bantam Kodachrome Adapter attached to the frame which fits the 8 x 10 camera back shown in figure 1.

Figure 5. Eastman 8 x 10 camera back with 5 x 7 assembly altered to make two exposures on a single film.

Figure 6. Inside view of the back described in figure 5, showing the divider in the 5 x 7 assembly.

grooves attached permanently to the larger frame, and the back may be quickly removed for use on other cameras or camera backs. This back has been adapted recently to a Type H Bausch & Lomb 5 x 7 photomicrographic camera. In this case the wood frame holding the back was smaller, and is placed in the same frame as the ground glass screen.

The construction of a multiplying back is slightly more difficult, but is well worth the trouble from the standpoint of convenience alone. An 8 x 10 Eastman view camera back reducing to 5 x 7 was used. The 5 x 7 assembly was removed from the larger frame with a broad chisel, sanded well to make it slide easily, and mounted in L-shaped channels as shown in figure 5. Stops are placed in the channels so that exactly half of the 5 x 7 ground glass covers the opening. This rectangular opening is made of ¼ inch Masonite as shown in figure 6. A small strip of wood, to serve as a divider, is placed in the center of the 5 x 7 assembly next to the ground glass in order to obtain clean-cut divisions on the negatives; see A, figure 6. In this view, the 5 x 7 assembly is drawn across the central opening to show the position of the divider. In use, of course, the divider does not obstruct the opening. This back has been found very convenient in making two X-ray intermediates on a single 5 x 7 film. Many 5 x 7 camera backs have dividers which may be used singly or in combination. In using these backs, the entire back must be removed and the divider shifted for each exposure.

Materials used in the construction of these backs is either Masonite, ¼ inch in thickness, plywood, or gum veneer. Other non-warping woods may be used. All new wood surfaces were painted with Kodalak No. 4 Brush lacquer which gives a satin black finish. Paraffin was used in the L-shaped grooves of the multiplying back to make the assembly slide easily. A small strip of thin brass was placed in the bottom L-shaped channel to take up the slack. Black Scotch tape was used to seal any cracks.

SUMMARY

1. Reducing backs, permitting the use of small films and plates on larger cameras, are described.

2. A multiplying back is described, with directions for alterations of a standard 8 x 10 camera back.

Motion Picture Photography of Rats

Edmond J. Farris, Ph. D.*

AFTER several years of experimentation and observation on the reproductive behavior of the rat, it was felt a photographic record of the findings would be of practical value. To secure a motion picture record, it was necessary to develop a photographic box for small-sized animals and a simple motion picture set-up that could be operated by practically any worker.

The most difficult part of the problem was to design a satisfactory box in which the rats would perform normally. Excessive heat from photographic lights usually inactivated breeding rats within three to five minutes. To avoid this condition, substitute rats were used always for preliminary focusing and the like. The photographic box finally adopted was arranged as represented in the figure. It consists of a clear white glass top and front, built in proportion to fill a 16 mm. film frame. The front door glass is 15⅞ x 12⅝ inches. The top door glass is 16 x 16 inches. Both front and top are detached easily for ventilation and cleaning purposes. The cage floor is likewise removable, and can be replaced by a flooring of wire screen mesh for greater ventilation purposes. The sides of the box are of wood construction. For background, we used silver gray satin finish enamel color, which served very well for any color rat or other small mammal. A removable opaque shield six inches in height was placed just behind the upper edge of the front door. This prevented any forward flare into the camera lens from a light placed over the top glass door.

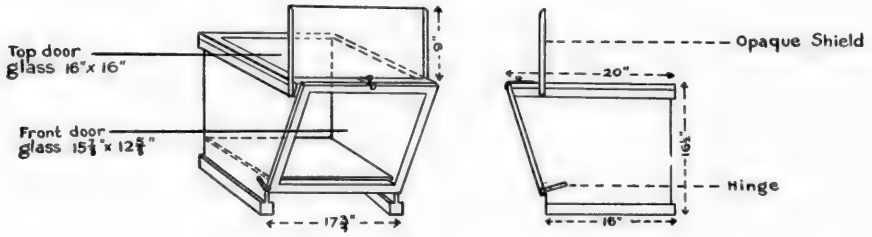
The motion picture set-up for photography of rats was quite simple. As illustrated in the figure, a pair of Kodaflectors with No. 2 photoflood lamps were arranged to illuminate the cage evenly from the front. To give roundness and detail to the animals, a reflector 18 inches in diameter was suspended about 18 inches over the glass top door. The reflector was equipped with a No. 2 photoflood lamp and a diffuser. An Eastman Cine-Special camera was placed approximately 38 inches in front of the cage.

*The Wistar Institute of Anatomy and Biology, Philadelphia 4, Pennsylvania. Received for publication November 3, 1943. This investigation was aided by a grant from the Samuel S. Fels Fund.

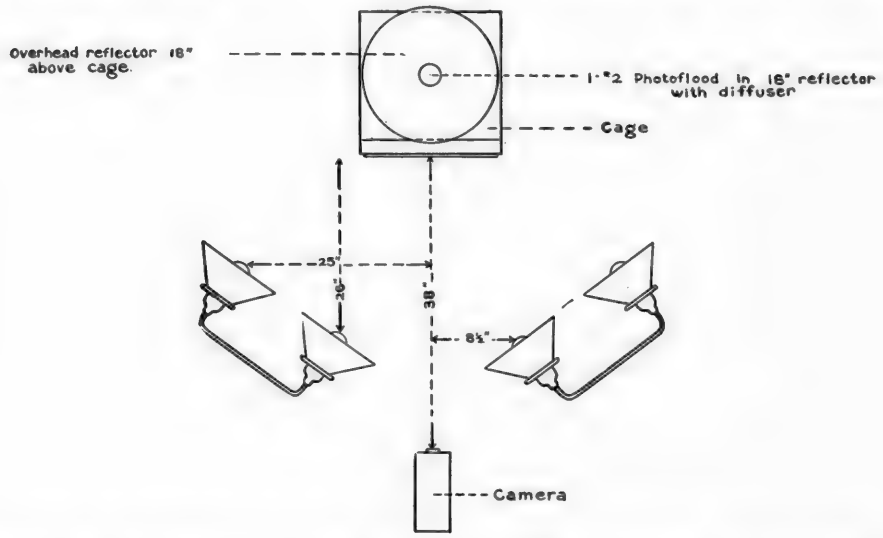
By this motion picture set-up for rats sharp pictures were secured of swift animal action. For the albino rat we used Kodachrome Type A film, a lens stop of f.4, shutter set at ½ open (1/50th of a second exposure) and a speed of 16 frames per second. The entire animal was in focus in every part of the cage at all times.

By slight modification of the animal photographic box and set-up the arrangement likewise served well as an obstetrical cage. The modification consisted of insertion of an electric clock in the rear panel and attachment of a time-lapse unit to the camera, so that photographs were

ANIMAL PHOTOGRAPHIC BOX



MOTION PICTURE SET-UP FOR RATS



taken automatically every two minutes. The lighting consisted merely of one 100-Watt overhead light in the 18 inch reflector, and two single 100-Watt lights in the center Kodaflectors.

Some Experience with Microphotography

Stanley J. McComb*

THE extent to which microfilm is being used today in medical centers, educational institutions and libraries is well known to all persons engaged in photography. Use of microfilm in business organizations, where it performs a multitude of recording operations, is no less familiar. There has developed a specialized branch of photography which is known as microphotography. This requires well-equipped laboratories staffed by men skilled in copying and in the making of slides and prints from microfilms. The Journal of Documentary Reproduction has advanced the scope, technic and methods of microphotography.

In this paper I shall attempt to describe how a few problems in microphotography were handled in the Section on Photography at the Mayo Clinic, where such work is definitely not routine.

The first extensive applications of microfilming in our department was the recording of the summary of the clinical and pathologic findings in cases in which necropsy was performed by members of the Section on Pathologic Anatomy. Such findings are invaluable as medical records and it was felt that their preservation against loss would be enhanced by copying them on microfilm. By using the Photorecord camera, some 36,000 protocols were copied, 800 to one 100 foot roll of film, one sheet to a double frame. The material was submitted to us arranged chronologically and numerically, so that once the camera was set up, lights adjusted and proper exposure determined, one had but to place a protocol in position on the copy board, make the exposure and proceed to the next one. As the copy was black typing on white paper, contrast positive film was used. This was developed in D11 for maximal contrast, by the Stineman system. (The Stineman system is a convenient method of developing short lengths of 35 mm film.) This is an example of the simplest form of microfilming, where the sole aim was the production of a negative record strip film for filing purposes.

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When one of the physicians expressed a desire for a great number of slides to illustrate lectures on anatomy, microfilm seemed to fill his needs, as expressed by him at that time. As we were novices in the field, several problems required solution. We had to consider the projector in which we planned to use the film, the method of film transport, the size of the aperture plate, and whether projection could be horizontal or vertical. The copy material, which was a text book, had to be kept level, and we had to have a method of masking ex-

Figure 1a. Illuminator; b, mask.

traneous material when the shape of the illustration did not coincide with the double frame size we planned to use. The illustrations varied considerably in size and as it was desired to have a maximal image size for each one it was felt that each illustration would have to be focused individually for accuracy of focus and placement. This meant a variation in the scale reduction and, necessarily, in the exposure. This was compensated for by varying the lens diaphragm approximately a fourth to a half stop for the different sizes, as determined by actual test. Two L-shaped pieces of black cardboard were used to frame each illustration as it was copied, and several wooden blocks of varying thickness were used to bolster the book and keep it level.

The following technic was evolved using the Photorecord camera. The image was centered and focused on the ground glass, the back of the camera containing the microfilm was substituted for the ground glass, the masks were placed in position and weighted slightly in order to eliminate the production of shadows on the copy, the diaphragm

opening was adjusted for the desired reduction, and the exposure was made. As some of the illustrations were in color, Panatomic X film was used. This was developed in D19, by the Stineman system, which was used in all of our processing.

Making the positive film involved a negative carrier, a method of illuminating the negative, and a suitable holder for the positive film stock. Photographing the negative at a scale of 1:1 by means of the Photorecord camera seemed preferable to making the positive by contact, as the former method would eliminate one great source of dust spots. A small illuminator in the department was suitably masked as a negative carrier. On a sheet of opal glass, which acted as a diffuser of the light, were pasted two pieces of cardboard, 35 mm apart, which provided a guide for the negative, figure 1a. The mask proper was in a hinged cover which was lowered to the glass and just enough pressure applied to insure a flat copy surface when the exposure was made, figure 1b.

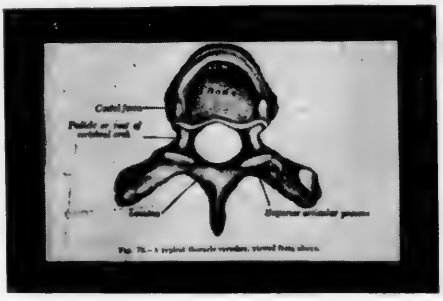

Figure 2. Appearance of projected image.

As negative density did vary slightly, readings were taken with the Weston meter on several representative frames with the negative on the illuminator and with the meter masked so that light acted only upon the center of the cell through a ½ inch circle. Exposure tests were made, the test negative was developed and then correlated with the meter readings so that the accuracy of the exposure could be checked as the work progressed. The positive print was made on contrast positive safety film, figure 2.

The completed microfilm was used in its original form for many months but disadvantages were noted. One of the chief disadvantages was the arrangement of the subject matter. In addition, certain portions of the film were used more frequently than were others, and this resulted in considerable damage to the film. Just recently, after many of the positives had been remade, the entire film was cut into individual frames and bound as slides. This permitted the sequence to be altered according to the desire of the lecturer.

Some new problems were encountered when a member of the Section on Urology desired, for teaching purposes, a microfilm composed

of about 300 roentgenograms, each with a legend, and about ninety textual frames or "readers". It was necessary to determine the best method for copying the roentgenograms and incorporating the legends in the positive print. Tests were made by filming the original roentgenograms, the intermediates, and prints that had been made from the intermediates, with just about equal success as far as preservation of detail was concerned. The necessity of a legend for each roentgenogram complicated the problem; therefore, it finally was decided that copying prints made from the intermediates and a legend at the same time would be most expedient, as the intermediates had to be made anyway for another purpose. Exposures would be rather constant, contrast could be controlled to some extent in making the prints and the overall handling of the work would be minimized.

A hinged cardboard mask was made. Two openings were cut in the mask: the first, which measured 5 by 4 inches, was for the print; the second, which measured ½ by 4 inches and which was situated ¼ inch below the first, figure 3, was for the legend. It previously had been determined that each typewritten legend should not exceed three single spaced lines of 4 inches. The best possible prints were made from the intermediates and the legends were typed on substance 32 white ledger paper. Each print and legend was numbered so that the material could be arranged properly before filming was started.

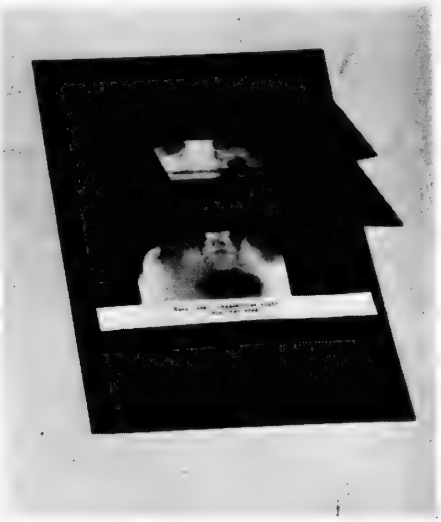

Figure 3. Mask for copying prints of roentgenograms.

The Photorecord camera was set up and focused to include all of both openings in the mask, although we now believe that a slightly smaller image size would have been a more sound procedure, as the pictures would not have been crowded in the frame. A narrow black border detracts in no way from the appearance of the projected image. If masking details are taken care of in making the negative, the problem is solved once and for all.

With the mask centered on the copy board in relation to the camera, and taped securely, the hinged mask was raised, a print and legend were placed in position, the mask was lowered and light pressure was applied to keep the copy flat as the exposure was made. Because of its fine grain and long scale, Panatomic X was used for the negative film. Full exposure and slight underdevelopment aided in keeping the negative soft in gradation. In making the positive strip film, the mask and method previously described was used. The film again was Panatomic X. Figure 4 shows how the projected image appeared.

Figure 4. Projected image of roentgenogram.

A field in which microfilming possibly may find great usefulness in the future is in the copying of roentgenograms. The subject came up for consideration in the Section of Photography a few years ago, because of the accumulation of roentgenograms in the files of the Section on Roentgenology. There were more problems to concern us than met the casual eye. Foremost was the one of preservation of the scale of the original roentgenogram, in which choice of film and illumination were prime factors. It was necessary to select one all-purpose film which would record high contrast common to certain type of roentgenograms and work fairly well with low contrast or flat appearing roentgenograms. Obviously, there would be some loss in fine detail in certain cases, for even with a film particularly adapted to this type of photography, processing must be for the average roentgenogram with no control over individual frames and, of course, no subsequent treatment. The roentgenograms had to be properly identified both on the strip film and by a card index for future reference. The method of handling roentgenograms of different sizes must be determined. All sizes could be copied from one camera position, or the camera could be moved back and forth so as to utilize maximal image size, with, of

course, attendent variation in exposure. Individual cases containing roentgenograms of different sizes could be broken to permit filming of one size at a time, but from the standpoint of later accessability this method does not recommend itself.

Tests were made to determine the feasibility of microfilming roentgenograms by using a special illuminator containing nine mazda bulbs each controlled individually by a switch, to secure a better balance of illumination over the entire film. Positive safety film was used. In cases in which an excessive contrast range existed, two exposures were made, based on Weston meter readings of areas of high and low density. Identifying numbers were cut in the roentgenogram by stencil when necessary, and a record of roll number and position and order was made for future indexing. From the standpoint of preservation of the roentgenograms as records, results were generally satisfactory. A commercial laboratory producing 35 mm advertising shorts subsequently took over the work and copied several thousand roentgenograms in the general pattern suggested. It was felt that methods and processing technics familiar to the motion picture industry, with accurate control over laboratory conditions, would be productive of superior results. Since that time, new emulsions of high resolving power with a long scale and low contrast have been developed which, along with improved processing, should result in even better recording of roentgenograms.

The problem must be well analyzed in the terms of individual conditions. Microfilming of roentgenograms is scarcely a task to be superimposed upon a busy photographic department so that the cost of equipment and new personnel must be weighed against the cost of space given over to filing. The number of roentgenograms that can be copied in a given period, say a day, by a competent staff must be checked against the number of original roentgenograms being made. The members of the Section on Roentgenology are by no means convinced, however, that microfilming of roentgenograms will solve the problem of film storage at the Mayo Clinic.

Experience with these few problems clearly demonstrates that microphotography is more than a process for reproducing originals on films. It involves many problems other than purely photographic technic, and these vary greatly in terms of the type of work undertaken. Ultimate use of the microphotographic record, proper identification, complete indexing for quick reference, proper certification of film copies for possible use as evidence in court, and, above all, proper arrangement of all material to be copied are some of the factors which must be kept in mind constantly in the making of a satisfactory microfilm record.

Fluorescence Photomicrography

by Erich Loewenstein*

MANY substances, after they have been irradiated with some kind of rays, exhibit the phenomenon of luminescence; that is, they glow in light of wavelengths which are almost always longer than those of the exciting light (Stokes Law).

The exciting light is usually ultra-violet light, or visible light, near the violet region of the visible spectrum. The specimen acts, so to speak, as an optical transformer. Luminescence may also occur under the effect of various other rays, such as cathode rays and X-rays. Light rays themselves can produce secondary luminescence, which in this case is called photo-luminescence.

When the specimen glows only as long as the exciting light source activates it, the phenomenon is called *fluorescence.*

If, however, the object glows for a while after the exciting light source has ceased, this phenomenon is termed *phosphorescence.*

Many substances, such as fingernails, teeth, fats, oils, silks, papers, sugars, etc., fluoresce brightly in various colors. Many botanical preparations, for instance, the stem of the barberry, many biologicals such as the vitamins, porphyrins, approximately all structures of the human and animal, impart some kind of fluorescence. The cell cytoplasm appears as a faint blue, some fibers as a striking blue, some others as a brilliant gray, etc. Vitamin A fluoresces both as concentrates, as well as in solution brilliant green. This fluorescence is found in various animal organs. In the human it is imparted by lipoids in the Kupffer and epithelial cells of the liver, in the fat cells proper, in the glands of the lactating breast, in pathological kidneys, and in many other parts of the body. Solutions of riboflavin (Vitamin B2) fluoresce yellowish green. Thiochrome (the oxidation product of Vitamin B1) fluoresces a bluish color. Fluorescent light is frequently used for the detection of single particles in a mixture of various substances, particularly in criminology.

* Scientific Bureau, Bausch & Lomb Optical Co., Rochester, New York. Presented at the Thirteenth Annual Convention of the Biological Photographic Association, September 10, 1943, at Princeton, New Jersey. Received for publication December 13, 1943.

Lately, however, fluorescence became important for the observation of very much smaller fluorescent particles under the microscope, such as histological, bacteriological, biochemical, petrographic, and other preparations. One can differentiate, for instance, in a histological preparation the fibers from fatty portions, from tissues, or from blood; one also can recognize foreign matter in preparations.

This technic makes visible small particles which cannot be observed under the standard microscope with daylight or artificial white illumination.

When observing specimens in transmitted light, one views the projected image of the contours or the silhouette of the objects.

In a fluorescence microscope, invisible ultra-violet light directed in the manner of dark field illumination is used to excite the fluorescent particles and to make them visible. One sees the fluorescent, self-luminous particles which show different colors and light intensities in various parts of the preparation. The color and intensity depend upon the chemical constitution and sometimes on the physical condition of each part of the preparation. Parts in the preparation which do not contain any fluorescent substances remain invisible. The dark field method of illumination is preferable, as the conventional bright field system gives hazy images due to scattered light, even when ultra-violet absorbing protective eyepiece filters are used.

After having obtained a satisfactory image under the fluorescence microscope, it is often desirable to supplement the visual observation for the sake of records with photomicrographs. Black and white prints show the differences in the brightness of the various particles. However, in order to make visible the brilliant colors of the fluorescing areas and to differentiate the various particles which fluoresce in different colors, it is desirable to record the actual color by taking photomicrographs in color.

THE APPARATUS

The apparatus required for fluorescence microscopy and photomicrography is in general the same as that for ordinary microscopy or photomicrography in daylight or artificial white light, except that special light sources, a dark field illumination system, special filters, and non-fluorescent immersion oils are needed.

THE MICROSCOPE

The conventional research or laboratory monocular microscope equipped with substage mechanism and a dependable fine adjustment

focusing mechanism is required. The ordinary silvered glass microscope mirror can be replaced by an aluminized mirror with good advantage. The aluminum reflector has a higher reflectivity than silver for the ultra-violet spectral region. The microscope should be equipped with a 16mm, 0.25 N.A. achromatic objective and a 4mm, 0.65 N.A. achromatic objective.

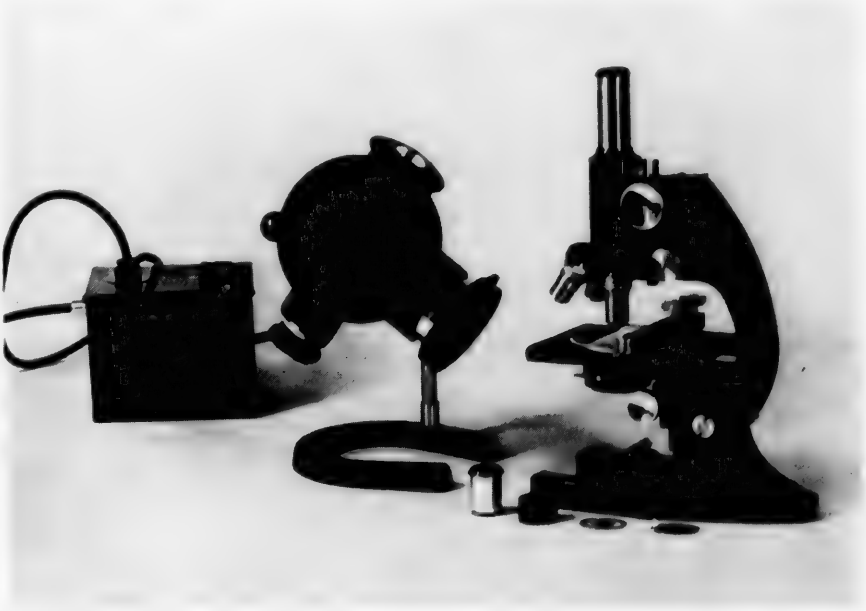

Figure 1. Fluorescence Microscope showing a general setup for fluorescence microscopy.

The substage condenser should be either the 1.25 N.A. Abbe condenser or the 1.40 N.A. aplanatic condenser. With these condensers should be used appropriate dark field stops. That is, when the 16mm. objective is used for observations or photomicrography, the top lens of the Abbe condenser or the upper two lenses of the aplanatic condenser should be removed and a dark field stop which limits the numerical aperture to not less than 0.25 should be inserted in the slotted ring beneath the condenser. When the 4 mm. objective is used the complete condenser should be in use with a dark field stop that will limit the numerical aperture of these condensers to not less than 0.65 N.A.

A drop of non-fluorescent oil, such as Shillaber's immersion oil, should be placed on the upper lens surface of the condenser to make immersion contact with the object slide. For visual work a drop of water between the slide and condenser gives good results. Any of the

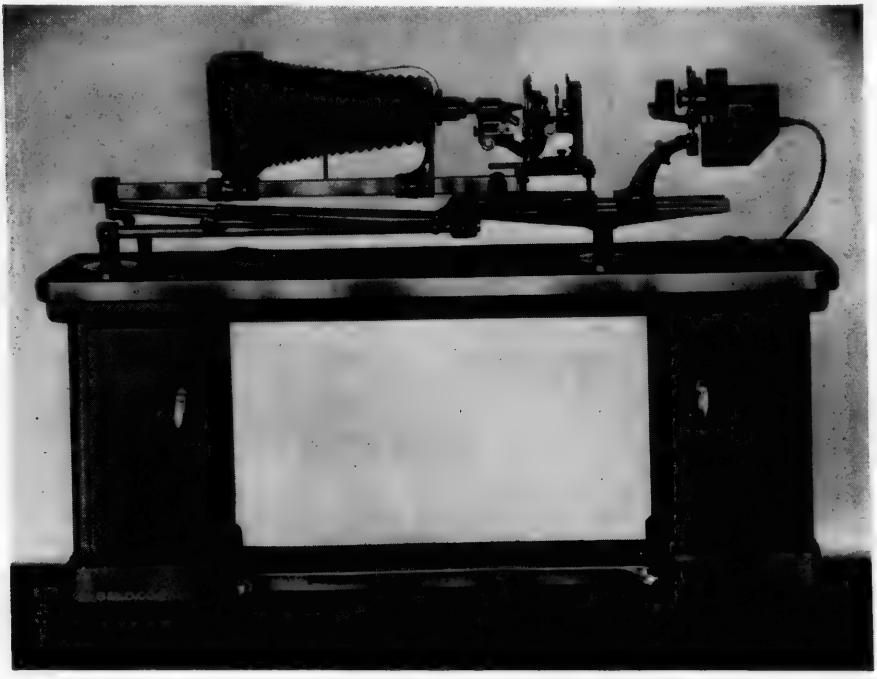

Figure 2. Photomicrographic Equipment in Horizontal Position with Research Microscope.

Huygenian eyepieces are quite suitable for use with these objectives in fluorescence work.

The Light Source

The ordinary incandescent lamp, no matter what its wattage or its type of filament, is not suitable for fluorescence microscopy. These sources may be said to emit some ultra-violet light, but the intensity of the emission is far too low to be of any use. The source must be one with high intensity in the ultra-violet region from 3000Å to 4000Å. Such a source is the General Electric No. H-4 capillary mercury arc. The lamp condenser preferably should be of quartz, but borosilicate crown glass transmits considerable ultra-violet light of wavelengths

well below the 3650Å region. The mercury arc is mounted in a standard microscope lamphousing, shown in figure 1. This lamp is operated from an A.C. line through a special transformer.

Special filters which transmit only the ultra-violet light and absorb the visual must be placed between the light source and the microscope for this work. The Corning red ultra filter No. 5840 has proved entirely satisfactory for absorbing the visual light and transmitting the ultra-violet emitted by the H-4 lamp, especially the 365 line of the

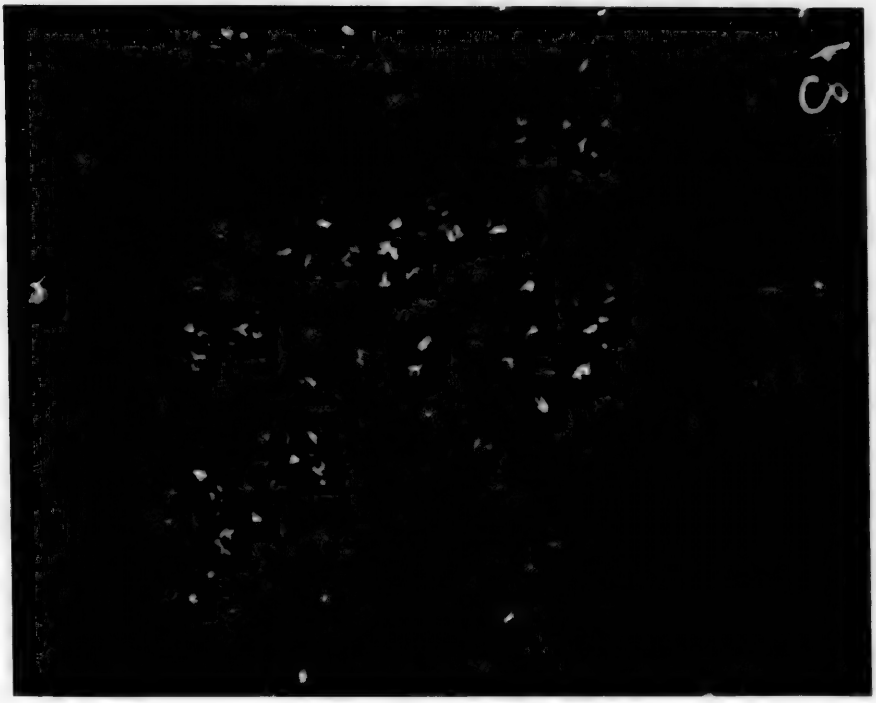

Figure 3

Tubercular Bacilli in human lung tissue. Paraffin sections approximately 6 microns. Treated with Carbol Auramine, concentration 1:1000, for 5 minutes. Mounted in Xylol—Clarite. Magnification 400X. Achromatic Objective 4mm, 0.65 N.A., 43X. 7.5 Hyperplane eyepiece. Fluorescence—Dark Field Illumination. Dark Field Stop 16mm with immersion oil.

mercury arc spectrum. Some visual purple light which is transmitted by this filter can be removed by introducing a Corning No. 4308 blue-green filter. It will not be found necessary to use this filter if the dark field stops, as recommended under the section on the microscope, are

used. A pale yellow filter, such as the Wratten 2A, or the Wratten Aero No. 1, or the Corning Noviol shade A filter No. 3389 must be placed between the eyepiece and the negative material to absorb any stray ultra-violet light that might get through the microscope. Sometimes it is advisable to change the eyepiece filter during the exposure to obtain a good color reproduction.

CAMERA

A photomicrograph simply gives a permanent record of what the eye can see through the conventional microscope. Since fluorescence may appear as monochromatic radiations throughout the visual spectrum, such records, if true, would have to be made in color. The record can be made in black and white but will be of far less significance than if made in color. Both black and white and color photomicrographs may be made of fluorescent material. Whichever type of photograph is to be made, practically the same requirements for good records hold.

The camera may be for use either in a vertical position or a horizontal position and the same microscope which one uses visually may be used with the camera. However, especially in fluorescence photomicrography, the microscope must be extremely rigid and free of such mechanical inhibitions as would cause it to shift in focus during relatively long periods of time.

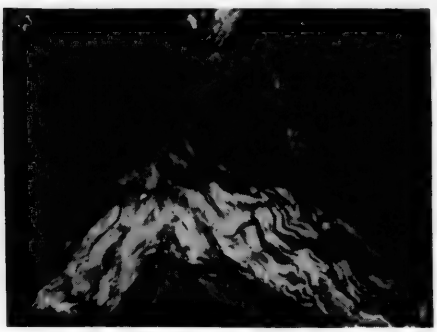

Figure 4

Stellate Ganglion of Cat.
Fixed in formalin-saline.
Frozen sections 10-20 microns.
Treated with Brilliantdianil gruen G, concentration 1:1000, for 6 minutes.
Mounted in glycerin.
Magnification 60X.
Achromatic Objective 16mm, 0.25 N.A., 10X.
5X Hyperplane eyepiece.
Fluorescence—Dark Field Illumination.
Dark Field stop 25mm without immersion oil.

The photomicrographs taken in the preparation of this article were made on equipment shown in figure 2 using a Bausch & Lomb research microscope and a Bausch & Lomb photomicrographic equipment in its horizontal position.

The optical bed on which the microscope camera and the illuminating equipment are mounted is supported on vibration absorbers in order that vibration does not affect the sharpness of the image during long exposures. The illumination was adjusted according to the classical Koehler illumination principles. Since this has been described in journals, only reference to where it may be located is given here.[1]

PHOTOGRAPHY

The light which is radiated by the specimen is all secondary and, as such, is low in intensity. Many photographic emulsions were tried before a satisfactory one was found. The Eastman Super XX Panchromatic Safety Film, Antihalation, was standardized on because it

Carotid Artery of Cat.
Cross section.
Tissue placed in formalin as soon as removed.
Frozen sections cut from 10 to 20 microns in thickness.
Treated with Thioflavin, concentration 1:10,000, for 10 minutes.
Magnification 40X
Achromatic Objective 16mm, 0.25 N.A., 10X.
5X Hyperplane eyepiece.
Fluorescence—Dark Field Illumination.
Dark Field Stop 22mm without immersion oil.

Figure 5

reduced the exposure to a minimum of 2½ to 7½ minutes. The conventional practice was followed for making the prints and lantern slides in black and white. Kodachrome Professional film Type B was tried for making records in color. The exposure time was calculated from the exposure time found with the Super XX Panchromatic films.

[1] Illumination in Photomicrography, by J. V. Butterfield, Journal of the Photographic Society of America. Vol. VIII, No. 3, March, 1942, p. 122.

"Illumination Systems for Photomicrography", H. W. Zieler—Journal of Biological Photographic Assn. Vol. II, No. 1, Sept., 1933, p. 16.

"Improved Illuminating System for Photomicrography with Immersion Lenses", Jean Kieffer—Journal of Biological Photographic Assn. Vol. V, No. 3, March, 1937, p. 103.

"Color Illumination in Photomicrography", O. Richards—Journal of Biological Photographic Association. Vol. IX, No. 2, Dec., 1940, p. 77.

"Faults in Photomicrography", John V. Butterfield—Journal of Biological Photographic Association. Vol. X, No. 4, June, 1942, p. 175.

The basis for determining the factor was the Weston speed of the Super XX Panchromatic film and that of the Type B. Kodachrome Professional film. The former film has a speed of 40 and the latter 6, which gives a factor of 6.7. This factor gave entirely satisfactory results.

Kodachrome Professional film, Daylight Type can also be used for color reproductions. For the special purpose of fluorescence color photomicrography it was found that the Kodachrome Professional Film, Daylight Type is superior to Kodachrome Tungsten Type B, since the Daylight Type records less blue light than the Type B. However, even when using the Daylight Type Kodachrome Film with Wratten Filter 2A between eyepiece and film, the blue color is still predominant. In correcting this predominance of blue the results become rather yellowish and the trueness of the colors is lost. The exposure required for Daylight Type film is somewhat less than for Type B. Experience is necessary to determine correct exposures. Experiments with Ansco color films are underway, and have given indication of good color brilliance.

SPECIMENS

Many substances fluoresce of their own accord as already indicated in the introduction. In this case the preparations are made in the conventional manner.

Abdominal Aorta of Rat.
Fixed in formalin.
Paraffin embedded and sectioned at 7-9 microns.
Treated with Phosphin, concentration 1:10,000 for 90 seconds.
Magnification 45X.
Achromatic Objective 16mm, 0.25 N.A., 10X
5X Hyperplane eyepiece.
Fluorescence—Dark Field Illumination.
Dark Field stop 25mm without immersion oil.

Figure 6

If, however, the material to be tested does not fluoresce by itself, fluorescent materials, so-called fluorochromes, have to be added. These are dyes which are absorbed by certain particles and single individuals,

such as, nerve tissue, fibers, cells, bacilli, which then fluoresce vividly when irradiated by ultra-violet or blue light.

In these cases, artificial fluorescence is generated which is called secondary fluorescence. Only very minute quantities of these fluorochromes and very dilute solutions are necessary to demonstrate the bright fluorescent colors. The time of staining is generally very short; therefore, the tissues, cells, nuclei are not affected by these fluorochromes.

The following figures show examples of work done on various materials in black and white. Unfortunately, color reproduction cannot be published.

Figure 3 shows lung tissue containing tubercular bacilli. The bacilli fluoresce brightly yellowish-green against the blue tissue and dark background. The section was stained with carbol-auramine.[2]

Figure 4 shows a section of stellate ganglion of the cat fixed in formalin-saline and stained with brilliantdianil gruen G. The yellow-green nerve fibres fluoresce brightly against the gray matter of the stellate ganglion.

Figure 5 shows the carotid artery of the cat, stained with thioflavin. The elastic fibres fluoresce very brilliantly against the dark background.

Figure 6 shows the abdominal aorta of the rat stained with phosphin, the elastic fibres, especially the elastic interna, fluorescing bluish white; the coagulated blood does not fluoresce in the lumen; the muscle tissue fluoresces gray.

This paper is by no means a complete coverage of the subject. It is intended mainly to stimulate the investigation of the application of fluorescence microscopy and photomicrography in fields such as histology, bacteriology, and chemistry.

There are, in addition, very broad fields open in which fluorescence microscopy and photomicrography can play an important role; such as chemistry, especially biochemistry, the food industries, mineralogy, vitamin research, biology, pharmacy, and other fields of endeavor.

Bacteriologists are urged to make experiments in the direction of detecting and identifying typhoid, diphtheria bacilli, streptococci, gonococci, whenever possible.

The author wishes to express his thanks to Mr. J. V. Butterfield of the Bausch & Lomb Optical Co., Scientific Bureau, for his assistance in taking the photomicrographs shown in this paper.

[2] "Demonstration of Tubercle Bacilli in Tissue by Fluorescence Microscopy" by G. Crossman and E. Loewenstein, J. Lab. & Clin. Med. 28:1349, 1943.

CHATS WITH THE EDITOR

"NOT how big, but how good." We feel like quoting this old advertising slogan, after doing a little research, regarding the professional standing of our Association Journal. Some of us may be inclined to look upon our periodical as a matter of course. Possibly, at times, not realizing the importance, or worth of some of the articles. One way of estimation is to note the frequency of abstracts appearing in contemporary publications. One, for instance is the *British Journal of Photography.* During 1943 our British colleagues printed abstracts from six U. S. Photographic publications, including our Journal. Collectively, the other five can be credited with seventeen abstracts, while our Journal was quoted on eight articles—nearly half as many as the entire other five.

Consider the popularity and diversity of fields covered by these five publications. The subject matter of our journal is limited to Biological Photography. Thus, we have every reason to feel that the material published must be useful and informative to warrant the printing of these abstracts.

The March 12 issue of "B.P." carried two articles from our September 1942 number—one by Dr. Wilson Footer, "Color Photography during Surgical Procedures", and "A New Method for Viewing Sheet Kodachrome" by A. A. Stone, R. Donald Reed, and Louis Schwartz. Adrienus Pijpers scholarly research on "Filming Vi Agglutination" (Dec. '42) was given an excellent review.

The "B.J." of March 19th contained an abstract of William F. Payne's good article on "Copying a Full-month Series of Intra-Oral Radiographs" (Dec.. '42.) The Oct. 12th "B.J." noted two articles, "Biological Photomacrography with Kodachrome Film" by Jay T. Fox, and Dr. Wilson Footer's analysis of "Photography and Medical Education" (June '43.)

The "B.J." of Dec. 24th devoted over a half page to Dr. Wilson Footer's paper "Routine Color Photography of the Cervix Uteri" and "Clinical Photography in Kodachrome" by William F. Payne (Sept.

'43.) To finish the British picture, the May 28th "B.J." carried this Want Ad—"Wanted copies of complete or partial sets, bound or unbound, of the Biological Photographic Assn. Journal."

In the United States, the Journal of the Photographic Society of America, carried three abstracts in 1943. "Biological Photomacrography with Kodachrome Film" by J. F. Fox, "Film Projection" by S. H. Bunchez, and "Filing Photographic Data" by R. McV. Wiston (June '43).

We can justly commend our Editor, the Staff, and the contributors, for this outstanding year's record. Featuring original illustrations and articles of advances made in Biological Photography has been the Editorial policy. The continuance of this, will assure the continued success of our Journal. Then we will always have something worthwhile to contribute to the World of Photography.

RAY MIESS.

NEWS FROM THE SERVICES

Lieutenant Alex Gravesen, formerly of the Cornell University Medical College and now at the U.S. Naval Hospital in Philadelphia, writes:

> "I am in the process of erecting a Biological Photographic Studio at the Naval Hospital, as up to date as can be done in a hurry with the least amount of priority material.
>
> "October 21st to 23rd the Military Surgeons of the United States had their 51st Annual Convention here in Philadelphia. This hospital had an exhibit consisting mostly of photographic work showing its various activities.
>
> "Our two friends from Washington, Lieut. Warren Sturgis and Capt. Ralph Creer were very much present. Captain Creer's 8 x 10 color photomicrographs made by his group at the Army Medical Museum are without a doubt the best I have ever seen. The motion pictures and animations which Lieut. Sturgis showed from the National Naval Academy Center in Bethesda are 'something'. The Association can be proud of being represented by such able men."

Speaking of the Naval Academy Center at Bethesda, another of our members has reported there for duty. Wilbour Chace Lown, until recently in charge of medical photography for the Massachusetts General Hospital is now Lieut. Lown, H. V. (s) USNR, and is working with Lieut. Sturgis on naval motion picture projects.

Association News

EXTRACT FROM THE SOUTH AFRICAN MUSEUMS ASSOCIATION BULLETIN

The Honorable E. C. Chubb, the Secretary and Editor of the Bulletin, with headquarters at Durban, South Africa, kindly sent us a copy of the following notice:

"We have received a sample copy of the quarterly journal of the Biological Photographic Association, an international organization formed in 1931 for the purpose of the advancement of photography in relation to biological and medical science. It consists of about sixty pages; and is of the very highest standard, both in regard to the articles it contains and in the quality of the paper, the printing of text and illustrations, and its general appearance. The address of the Secretary is University Office, Magee Hospital, Pittsburgh, Pennsylvania, U.S.A."

CLINCIAL PHOTOGRAPHY IN ENGLAND

We are indebted to Mr. George A. Jones, on the Programme Committee of the Association for Scientific Photography for the following account of the Association's first meeting on clinical photography:

"At a meeting of the Association for Scientific Photography held on September 18th at the Middlesex Hospital, London, W.1, Dr. H. Mandiwall, L.D.S., stressed the particular qualities required in Clinical Photography. In his opinion these were: (a) a simple straight-forward record with perfect definition; (b) a self-explanatory picture but nevertheless one which did not include unessential portions; (c) a well-presented print, as much care being taken in the mounting and finishing as in a studio portrait; (d) in the case of colour photographs the colour must be true to the original. This is of particular importance in skin diseases which are characterised by the colours of the part affected. It was suggested that a Clinical Group should be formed within the Association which would discuss the special aspects of this work and compare technique.

"Another point was the collaboration between the photographers and manufacturers of apparatus. The requirements of clinical photography were in many cases distinct from those of studio or outdoor work and it would be of great advantage to have certain apparatus specifically designed for the work.

"In opening the meeting, Mr. T. Pomfret Kilner, F.R.C.S., stressed the importance of standardisation in technique, particularly in his own

sphere of plastic surgery. The photographs taken before and after treatment required to be strictly comparable as regards type of film, exposure, lighting and so forth. He illustrated his remarks with views of a simple equipment employing a Leica camera and Photoflood lighting which enabled photographs to be taken at any angle and which could also be used for copying radiographs or documents. He recommended that ortho materials be used for the majority of work; before the war he had always used Agfa Isochrom film.

"Miss Hilda Marsden showed examples of the work done at the Christie Hospital, Manchester, using a half-plate camera with studio technique. She laid special stress upon the importance of lighting, particularly in delineating the outlines of growths and other protuberances.

"In the discussion which followed the papers, Mr. Andrews (London County Council) showed illustrations of a convenient set-up for photographing patients in bed, which was made with the aid of a step-ladder such as is always available in a hospital. The camera was fitted to the top of the steps with the usual ball-and-socket joint and could be directed in any required direction. By means of interchangeable lenses, and lights also fitted to the top of the steps at varying angles, he was able to take a variety of photographs of a patient including any amount from head only to full-length. He had found that a 4¾-in. lens was adequate for full-length and an 8-in. for head-and-shoulders. A 14-in. lens gave a close-up of an individual part with the patient lying flat some 5-ft. below the camera.

"As a matter of interest, Mr. Andrews showed a photograph of a patient with one brown eye and one blue, taken with ortho film without a filter. Only one Photoflood lamp was used and the tone rendering was excellent.

"Mr. Hennell (Metal Box Co.) said that he had taken several thousand clinical photographs in colour during the war and used Sashalite flash-bulbs exclusively for illumination. He considered this was the best method of tackling a variety of jobs and agreed with Mr. Kilner as to the necessity for standardization. He exhibited several samples of his colour prints taken with a one-shot camera and produced by a toning process of his own.

"Several other speakers took part in the discussion and it was generally agreed that clinical photography should be undertaken by a professional photographer who would find it advantageous, if not a necessity, to make a special study of physiology and anatomy. It was not considered reasonable to expect a doctor or surgeon to do his own

routine photography even though that might lead to the production of the best results from their point of view. It was pointed out that the majority of hospitals, while equipped for radiography, were not well equipped for clinical photography."

MEETING WITH THE BINGHAMPTON TECHNICAL SECTION OF THE P.S.A.

On November 2 the Binghampton Technical Section of the Photographic Society of America met in the Art Gallery of the Arlington Hotel. The notice about the meeting contained the following paragraph:

"In spite of war-time inconveniences the newly installed Officers and Program Chairman feel that our meetings should maintain a high level and progressive outlook. At this meeting a comprehensive survey of both medical and zoological photography will be presented. We are fortunate in being able to obtain the services of two leaders in the Biological Photographic Association and we are sure that in no way will you be disappointed with the program to be presented."

After the meeting, Lloyd Varden, who planned the program and the meeting in all its details, wrote us a letter about it:

> "Everyone thought that this last meeting was the most successful one which we have had. Through the B.P.A.'s kind co-operation we had an excellent display of color-transparencies, and prints, both black-and-white and color.
>
> Stella Zimmer started the program and she did a marvelous job. She reviewed the purposes and values of medical photography and then discussed a typical medical photographic set-up, using as the basis of her discussion the department at Syracuse University. She illustrated the talk by slides. After a very excellent discussion on the above topics, which she made the more interesting by relating several personal experiences, she showed a series of slides to illustrate the type of work done in her department.
>
> Following Stella, Art Smith gave his presentation on biological photography, emphasizing the zoological aspect. He interspersed his more serious comments with humorous remarks and showed several slides that he had made from old photographic literature. In addition to showing typical slides of zoological photography, he showed slides on methods of lighting and discussed this problem very ably.
>
> We had a short question period at the conclusion of both talks."

The Army Medical Museum of Washington, D.C. sent the fine exhibit of color transparencies shown at our Princeton meeting to Binghampton for this occasion. On view too were selected prints from our

national Salons, and prints and transparencies contributed by individual members. We cannot mention them individually as we have not the complete list, so we can only tell them collectively that judging from Mr. Varden's letter the display made a fine showing and gave the visitors a new insight into the scope of biological photography.

NEW WORK LISTED BY MEMBERS

You may be interested in the new-work items coming in on renewal cards, because some of it may parallel work you are doing yourself. One of the purposes of the Association is to give you information about other photographers in your own field. If you are about to undertake unfamiliar work in which some of our members have already had experience, we will gladly furnish their names and addresses, or send them questions which you would like to have answered.

There are a number of omissions in the list below. For one thing, many renewals will reach us after this list has gone to the Editor. New motion pictures are not listed, as they will be published in a report of the Motion Picture Committee. And finally, no mention is made of work being done in or for the armed forces because full details will not be available until after the war.

Mr. John J. Beiter, Rochester General Hospital, Rochester, N. Y., is developing the use of *colored illuminated back-grounds* for the Kodachrome photography of pathological specimens. He has also been doing Kodachrome *photomicrography* of sulfa-crystals by *polarized light.*

Mr. J. D. Brubaker, 805 Greenleaf Street, Evanston, Ill., is doing research work on the *design* of *optical instruments* for visual education. Judging by his past interests, we assume that some of these designs are for *endoscopic photography.*

Mr. Jay T. Fox, Seaford, Long Island, N. Y., has been working on *photomacrographs of mineralogical specimens.* "Mineralogical Photomacrography" May 1943; Rocks and Minerals, Peekskill, N. Y. Natural History Magazine of American Museum of National History, N.Y.C. June 1943 Kodachrome cover.

Mr. H. Lou Gibson, Eastman Kodak Co., Rochester, N. Y., in addition to surgical motion pictures which will be listed later, has done considerable work in *close-up photography of vitamin-deficiency manifestations* in eyes, skin and oral cavity.

Dr. Ferdinand Koch, 424 Hamm Building, St. Paul, Minn., is continuing his work on photography of the *human ocular fundus.* He has

two articles in press; one on a modification of a film holder, the other on the use of filters with Kodachrome artificial-light film to approximate daylight in color-values.

Mr. Frederick Kraus, 31 Lincoln Park, Newark, N. J., is recording various types of *occupational dermatoses* on Professional Kodachrome, Type B.

Mr. Maxwell J. Leon, 1637—47th Street, New York, N. Y., is carrying out experiments with *fine-grain developers on 35mm. fluorographic film.*

Miss Sylvia Lecher, 4320 N. Lake Drive, Milwaukee, Wis., who was formerly in the photographic laboratory of the Eloise Hospital, has taken up *agricultural photography,* and is at present working on pictures of farms.

Mr. Adolph Marfaing, Columbia Institute of Ophthalmology, New York, N. Y., is doing *microphotography,* in addition to his work on the photography of the *eye,* with which members who have seen our Salons, are familiar.

Dr. John W. Richter, 35 Park Avenue, New York City, delivered a table-clinic on *intra-oral Kodachrome photography* at the New York State Convention in Syracuse.

Mr. Henry Roger, Rolab Laboratories, Sandy Hook, Conn., has been doing research on the technique of photographically recording the *movements of human eyes* with reference to psychiatric research.

Mr. Albert Sadler, Eloise Hospital, Eloise, Michigan, has furnished the illustrations for *"Pictorial Clinical Medicine",* a companion volume to Osler's *"Principles and Practise of Medicine",* by Gordon B. Myers, M.D. of Wayne University, and Henry A. Christian, M.D. of Harvard University. Some of the negatives for this work were made by Lieut. C. Graham Eddy before he left Eloise for the Army. Mr. Sadler made the other negatives and all the prints. The book is being published by the A. Appleton Century Co.

In addition, Mr. Sadler has recently been working on the problem of recording, by means of motion pictures, the *response of psychopathic patients* to music therapy.

Mr. Lloyd Varden, formerly with the War Production Board, Washington, D. C., has returned to Ansco in Binghamton, N. Y. His interest in *fluorography* continues, and he recently published a chapter on that subject in the "Handbook of Medical Physics". He has also written a series of three articles for the Journal of the Photographic Society of America on *"The Response Characteristics of Photographic Layers to Radiation",* Vol. 9, Nos. 1, 2 and 3, Jan. to Mar., 1943.

Mr. Glen Cordell Wade, Salem Deaconess Hospital, Salem, Oregon, has been experimenting on *luminography* both with and without "Fluorescite". Mr. Wade is also interested in the use of *infra-red photography* in industrial medicine.

Mr. Donald Wald, 624-¾ N. Sweetzer Avenue, Los Angeles, Calif., has developed a technique for making *reduction Kodachrome transparencies* from large-sized Kodachrome.

Sustaining Members

Some individuals who have a deep interest in the advance of scientific photography help finance a wider range of activities for the Association by becoming Sustaining Members. The privileges of Regular and Sustaining members are the same. Either type may be chosen each July when the dues are payable. A Sustaining Member pays slightly more in dues than three regular members. But because only one Joural subscription need be furnished him, he contributes as much to the Association's available funds as eight regular members. It is apparent that he is a valuable addition to the Association financially. More than that, his gesture of interest and cooperation in taking out this type of membership is cheering to the Association as a whole. We take pleasure in thanking the following Sustaining Members for their friendly support:

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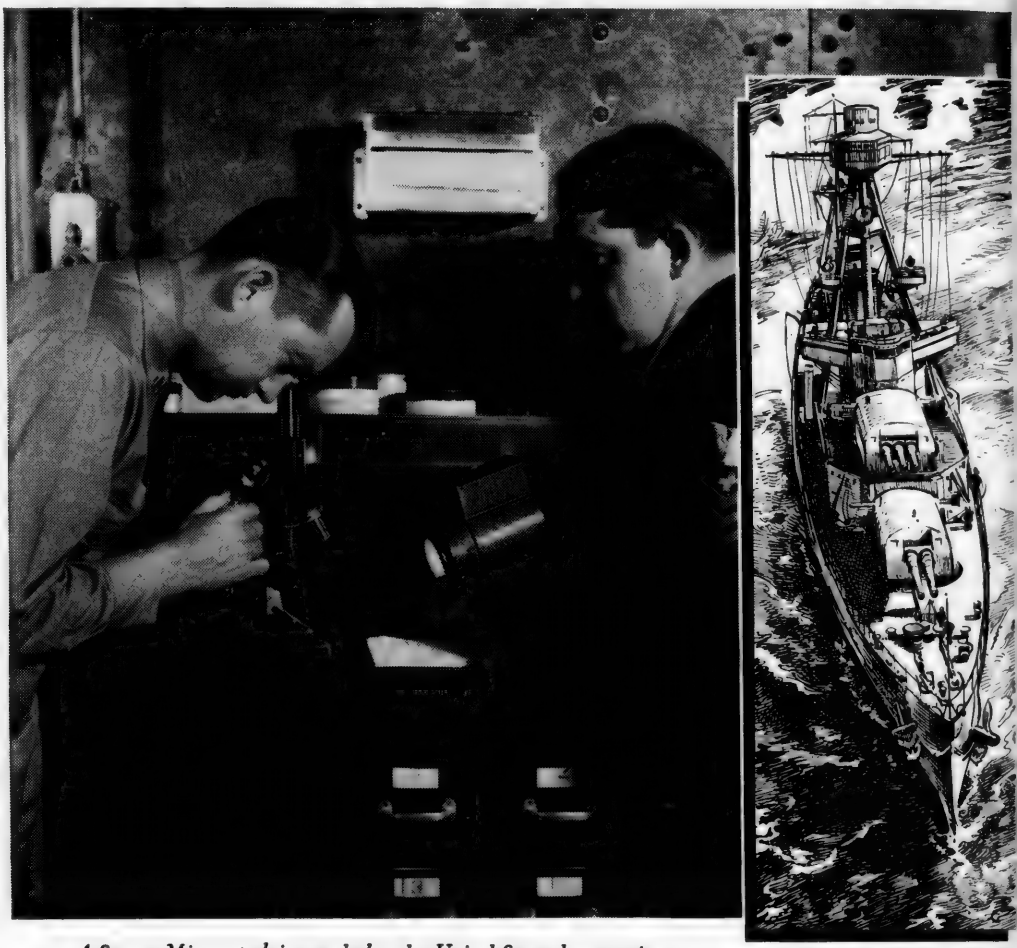

A Spencer Microscope being used aboard a United States heavy cruiser.

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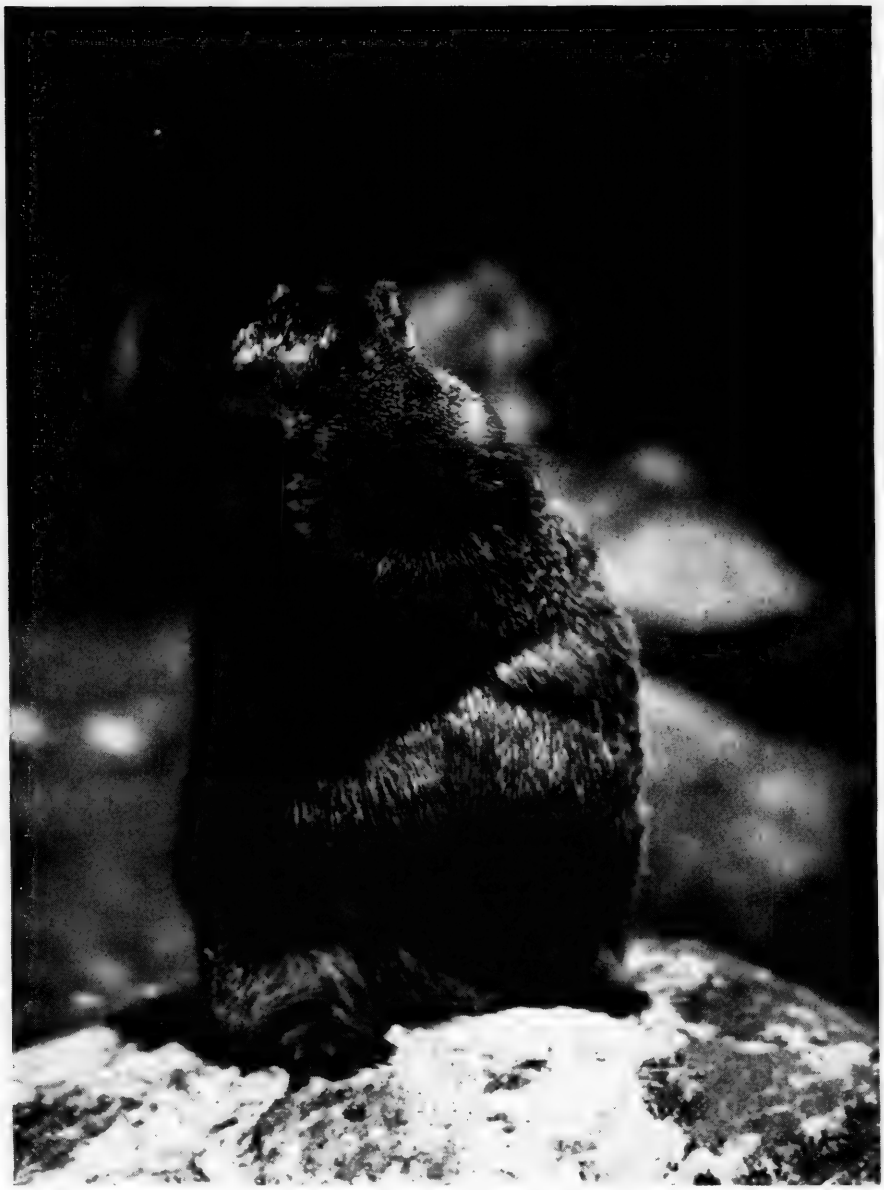

WYOMING MARMOT

Photographed by Ray Miess, Milwaukee, Wisconsin, using a Voightlander Bergheil 6½ x 9 cm Heliar F.4.5. The film was Panatomic X Pack in DK 20. Bromide print developed in Amidol.

Kodachrome Photomicrography of Stained Slides

R. P. Loveland*

THE making of stained microscope slides has become a standardized technic which has been greatly aided by the availability of biological stains certified by a national commission. The consistency of the results has allowed diagnoses to be made upon evidence furnished by changes of hue.

The introduction of the Kodachrome process of color photography has made the photography of stained sections in natural color a simple matter but in order that the color reproduction may be satisfactory it is necessary to take certain precautions.

There are two principal problems: One lies in the difficulty of reproducing the color of some of the common biological stains in Kodachrome photomicrography. The other is concerned with the color of the light actually used in making the photomicrograph.

The first problem has been considered a special difficulty for photomicrographers, but it proves not to be essentially so. Certain aniline dyes are not reproduced well by a three-color process, owing to the sharp limit of their spectral absorption and the particular positions in the spectrum of these absorptions. This is a difficulty that would occur with any three-color process, although not necessarily with the same dyes. Both eosin and fuchsin belong in this category, both losing their brilliant color and reproducing in a Kodachrome picture as a desaturated blue-red. Unfortunately, they are the two biological stains that are probably most frequently included among those used on specimens submitted for color reproduction; eosin, because it is the most common biological stain; and fuchsin, because it is used in the most popular triple stain. Specimens stained with the triple stain are especially attractive for three-color photography.

Fortunately, these two cases can be corrected by the use of a liquid filter of a neodymium salt. This filter is valuable because it effectively corrects the trouble with the addition of only a negligible

* Communication No. 954 from the Eastman Kodak Research Laboratories, Rochester, N.Y. Received for publication October 22, 1943.

general pink hue. The soluble salts of neodymium are too hygroscopic to handle conveniently, so neodymium carbonate† should be used. A stock solution is made up as follows:

	Avoirdupois	*Metric*
Neodymium carbonate, C.P.	110.0 grains	6.0 grams
Glacial acetic acid	2.0 drams	7.0 cc.
Water to make	4.0 oz.	100.0 cc.

Using 400.0 cc. per liter (1 dram per 32 oz.) of the stock solution in water in a water cell 10 mm. (0.4 inch) thick will allow satisfactory reproduction of these stains. For absorption cells of other dimensions along the illumination beam, divide the 400.0 cc. by the thickness of the liquid in centimeters (or by the thickness in inches and multiply by 0.4).

"Didymium glass" filters, such as the Corning No. 5120, should also be satisfactory, but an equivalent absorption corresponds to a very thin piece of glass, less than 2.0 mm. thick. This thickness might prove satisfactory, however, because of the considerations discussed later.

The difficulties arising from the color of the light are in some respects peculiar to photomicrography.

Kodachrome films are adjusted for use with light of a definite composition. Light which appears "white" covers a wide range of composition; thus in comparison with the light of an incandescent electric lamp daylight is very blue.

Kodachrome films are therefore made for use with two different light sources, "daylight" and "tungsten filament electric light." In practice, however, quite small differences in composition between the light that is used and that for which the film was adjusted will affect the color rendering.

The system of rating the color of light is to state that the color of the light corresponds to that of a special lamp known as a perfect radiator or "black body," which is operated at a stated temperature, denoted in degrees Kelvin (°K., obtained by adding 273° to the corresponding temperature in degrees Centigrade). The light source is said to have a "color temperature" equal to the actual temperature of the black body. The color of light is bluer with higher color temperatures, and warmer (more orange) with lower color temperatures.[1]

Kodachrome films for daylight are color balanced to give best rendition of the subject in bright sunlight on a clear day, the color temper-

† This may be obtained from the Maywood Chemical Company, Maywood, N.J.

[1] R. S. Estey (This journal, 9, September, 1940, page 18).

ature of which is about 6000°K. For artificial light, however, the 16-mm., 8-mm., and 35-mm. films are made as Type A adjusted to a color temperature of 3450°K., the temperature of a Photoflood lamp, while the Kodachrome Professional Film is made as Type B adjusted to a color temperature of 3200°K. With tungsten lamps, the correct color of light can be secured in one of two ways: 1, lamps can be burned at exactly the intended voltage; 2, the color of light of the lamps in use can be checked by the Eastman Color Temperature Meter[2] and the voltage adjusted by a rheostat to secure the correct color; or, if it is inconvenient to adjust the voltage, the proper compensating filter can be determined with this meter and applied at the camera lens.

In normal photography with Kodachrome, after the illumination has been adjusted to be correct for the particular type of film, e.g., by using the standard tungsten lamp (3200°K.) for Kodachrome Professional film, Type B, the lamp is allowed to shine directly upon the subject and the picture is taken. In photomicrography, however, an elaborate optical system is interposed between the illuminant and the subject. Moreover, the illumination optics often contain high-aperture lenses, f.1 or greater, having absolutely no chromatic corrections; the image of the filament formed by the lamp condenser is in reality a rainbow series of images along the axis which is relayed into the short-focus substage microscope condenser. This affects the illumination quality, of course, and the quality of the light leaving the lamp is not the same as that which reaches the image plane. This is easily tested by setting up a ground glass outside of the camera but in the same plane as that of the camera and bringing some of the light from the lamp to it around the photomicrographic system by an outside circuit. Almost invariably the illumination of the ground glass of the camera will look green. We made a study of this effect and analyzed the spectral quality of the illumination at various points along the bench from filament to ground glass. One important observation is that the spectral quality of the illumination in the object plane and in the ground-glass plane is no longer that of an incandescent black body. A color temperature meter cannot therefore be used to correct this illumination defect by varying the lamp current or by the use of photometric filters. Such a meter is designed[2] to work with the original illumination from a lamp, and it is assumed that the spectral distribution is that of a black body.

A photomicrographic system at high magnification was actually set up in which the illumination quality was unchanged throughout the system, that is, it was equivalent to the simpler system where the illumi-

[2] Lowry, E. M. and K. S. Weaver: "A Color Temperature Meter." J. Soc. Mot. Pict. Eng. *32*, 298 (1939).

nation shines directly on the specimen and a well-corrected camera lens is used. For this purpose, an achromatic lamp condenser was used, together with an apochromatic objective as the substage condenser. Since the lenses themselves can be color filters, all of them had to be selected for lack of color. This required considerable care since the most common trouble is absorption of the ultraviolet and far blue. A piece of glass that has only a slight yellow (minus blue) tinge may act as if it were a filter of a much deeper shade of yellow, since the ultraviolet is recorded as blue on Kodachrome film. The optical system used did not cause a deterioration of the original illumination system. It is preferable, however, to consider the defects produced by a more usual system as due to a filter and to make the correction by adding another compensating filter. In this way all the troubles are grouped together and specific analysis of them is unnecessary.

We have found it advisable to mount all specimens for color photomicrography in a colorless substitute for balsam, e.g., methyl methacrylate or polystyrene, and also to use a colorless immersion medium instead of cedarwood oil, several types of which are available on the market. This is less necessary if all the ultraviolet is to be eliminated, as will be discussed later.

Just when these effects become serious depends upon a number of variables; frequently the specimen is such that its colors are not critically affected by this defect. This is usually the case in very low-power work and the use of an achromatic and colorless lamp condenser especially extends the limit below which compensation is unnecessary with increasing magnification. However, at high magnifications with a compound microscope, the best technic is probably to include a compensating filter.

When compensation is to be used for any reason, it is recommended that the ultraviolet and far blue be eliminated by an appropriate filter, since this region constitutes the largest and most unpredictable variable, especially from one photomicrographic bench to another. The Wratten 2A filter is suitable for this purpose and is one of the few filters of similar absorption that is sufficiently light-stable. The yellow cast that would normally be produced in the color picture by the use of such a filter can be allowed for in this case by merely altering the compensation that would otherwise be used.

However, it is sometimes advantageous to compensate by merely reducing the ultraviolet and blue, when there is an excess of this component, as, for instance, when a carbon arc is used. A solution of sodium nitrite has an absorption maximum at about the same wave length as

the peak of the excess ultraviolet of the carbon arc and makes an especially suitable filter for absorbing it. In determining the proper concentration of the nitrite solution for a particular arc, it is necessary to vary the concentration of the sodium nitrite solution in a geometric ratio (0.5%, 1%, 2% etc.) in order to obtain equal increments in effect in the yellow component of Kodachrome (see later).

A water solution of sodium-dinitrobenzene sulfonate* has proved to be particularly suitable for use as a variable liquid filter for absorption of the ultraviolet and blue end of the spectrum. There is no practical transmission of radiation below the long wave-length limit of its absorption**, and this absorption limit can be varied with the concentration of the compound to absorb an increasing amount of ultraviolet, then violet, and finally blue light, when it becomes, of course, a yellow filter of variable depth of color. Moreover, its effect on Kodachrome in eliminating excess blue is proportional to the concentration of the solution, except in extremely dilute and very concentrated solution when its effect is also proportional to the geometric ratio of the concentrations. It is most convenient to use this compound from the following stock solution:

Sodium 2,4-dinitrobenzene sulfonate*	20.0 grams
Water to make	100.0 cc.

The solution should be allowed to stand for at least half an hour, and then be filtered. The flocculent brown material that does not dissolve acts as a clearing agent, so that the filtrate is a crystal clear yellow. The stock solution should be stored in a well-stoppered brown bottle.

Systems of Color Compensation

There are three general systems of compensation which can be used. Considering all the illuminants employed for photomicrography, any one of the three systems might be the simplest or most practical in a given situation. Since the compensation is chiefly due to the optical aberrations and glass absorptions of the optical system, there will be some variation in the requirements for correct compensation from one case to another.

An outline of these three alternative compensation methods is given in Table I. The requirements for the compensation filters vary, of

* This compound may be obtained from most chemical supply houses, or from the Chemical Sales Division of the Eastman Kodak Company, Rochester, N.Y., as Chemical T-4276.

** This is true of the technical grade only. The very pure compound has a transmission band in very dilute solution at — *300 mu.*

course, with the nature of the departure from a neutral color balance, but they should remain constant for one equipment.

TABLE I

Method	Compensation Filter (Variable as needed) No. 1	No. 2	Advisable Ultraviolet Absorbent	Original Defect
I	Yellow Absorbent for ultraviolet and Blue	A. Magenta or B. Green	Variable for compensation (Filter No. 1)	1. Excess ultraviolet and possibly blue (blue cast in picture) 2. A. Green cast *or* B. Magenta cast
II	Blue (or blue-green) Primary color filter	A. Magenta or B. Green Primary color filter	Complete, such as Wratten 2A	1. Yellow cast 2. A. Green cast B. Magenta cast
III	Photometric filter A. Amber B. Bluish *or* Variation of the lamp current	A. Magenta or B. Green	Complete, such as Wratten 2A	Any color defect of small amount

A completely neutral color balance can always be restored by adjustment of two of the three color components, i.e., by adjusting the blue-yellow (minus blue) balance and of the green-magenta (minus green) balance. This procedure is much simpler if a change in the color of the illumination during such adjustment affects only one color-sensitive element in the film at a time, so that the two adjustments are entirely independent of each other. The defect in color balance may involve more than one primary color, but if that due to one of them, such as blue or green, is predominant either as an excess or as a lack, it alone may be obvious. In this case, the need for a second filter may only be evident after this has been nearly corrected.

Method I consists in partial absorption of the ultraviolet, extending the absorption into the blue if necessary, to restore the correct color balance. The filters for this procedure have just been discussed; further details will be given later. In Methods II and III it is advisable first to eliminate this region (ultraviolet into the blue) completely by absorption.

If compensation is required at all, it usually includes elimination of the greenish cast already mentioned; indeed, only the magenta filter may be needed in some cases, particularly if the variation of the lamp current is used as the other compensator, as is discussed under Method III. Since the compensation is principally due to the optical system, the amount required will differ among individuals. A liquid filter is therefore most practical when the exact concentration required is de-

termined as described later, if the concentration of this filter given in the typical example for the method is not satisfactory. A solution of neodymium salt can be used as the magenta filter, but it is not well suited to the purpose and may require too great a concentration of salt in solution. Its chief advantage is its stability since, unfortunately, there is no really stable magenta dye. Moreover, it is almost impossible to obtain an identical color in a dilute dye filter by successive weighings from a commercial dye sample. Therefore, a stock solution for use in making up a magenta filter by simple dilution with ordinary volumetric methods is supplied by the Kodak Research Laboratories. It will keep indefinitely in its brown stock bottle.

A few cases have been encountered, principally in metallography, where a dilute green, rather than a magenta, filter is required for Filter No. 2. A solution of nickel sulfate containing some sulfuric acid is very satisfactory for this purpose, since it is not only very stable but acts as a true green in Kodachrome photography, i.e., the magenta component of Kodachrome film is unaffected while the other two are equally affected. The following formula is a convenient stock solution:

Nickel sulfate (as $NiSO_4$ 6 H_2O)	20.0 grams
Sulfuric acid, concd.	1.0 cc.
Water to	100.0 cc.

The bottle should be tightly stoppered, preferably with a clean rubber stopper.

Method III is very useful if only slight compensation is needed. It can be employed either by varying the current through the incandescent lamp or by using the pale gelatin Eastman Color Compensating Filters (CC13—CC15; CC23—CC25), which can be considered to be dilute photometric filters, in order to obtain the proper blue-yellow balance. A filter, such as the Wratten No. 2A or a solution of sodium nitrite (2% or stronger), should be included to eliminate the ultraviolet. The proper concentration of magenta filter will probably also be needed to correct the green hue. However, the magenta-green balance is affected by the change of current (or by the photometric filter) to about one-half the extent of the blue-yellow balance. Therefore, for an appreciable amount of filter compensation, Method III is not as simple to apply as Method II.

For most compensation, other than with the specific cases just discussed, Method II seems preferable. The introduction of the Wratten No. 2A filter in the beam to remove all ultraviolet usually makes it directly applicable because this filter in itself would make the Kodachrome film reproduce with an excess of yellow.

The method could be considered as compensating for the spectral defects by use of two dilute filters of the same subtractive primaries as help compose the tones of the Kodachrome reproduction, namely cyan (minus red) and magenta (minus green). Two filters of the additive primaries, such as blue and red, could be used. Each would merely affect two of the Kodachrome colors at a time, preferably equally, leaving the third relatively unchanged. In practice, it has been found best to use a blue filter that affects the cyan and magenta components equally and thus directly compensates for excess yellow, together with the magenta liquid filter discussed previously. The blue filter, then, allows the adjustment of the yellow component of the Kodachrome picture as well as does the sodium nitrite or a yellow filter (Method I), although in the opposite way. A stock solution of a blue liquid filter is also available from the Kodak Research Laboratories. In general, the same considerations hold for it as were discussed concerning the magenta filter, except that it must be stored in Pyrex containers. As with the magenta filter, the effect on Kodachrome film varies in nearly direct proportion according to the concentration of the coloring matter in solution. The two filter solutions may be mixed together in the same cell in any proportion. If two cells, particularly cells 10.0 mm. thick, are available, it is more convenient to keep the two solutions separate, at least until their correct composition is well established.

The dye solutions as used are very dilute, and it is convenient to have a working stock solution 100 times more dilute than the original stock, i.e., 10 cc. of the original stock diluted to 1000 cc. with distilled water. The dilution should be done carefully. The effect of these filters on a Kodachrome picture is directly proportional to the concentration of the dye in each case.

Criteria for Correct Compensation

Using a number of typical equipments with the standard photomicrographic methods of illumination, some examples of the compensation that was required in these cases are given in the direction sheets accompanying the filters, together with the proper dilution of the liquid filters from stocks. If the balance obtained using the filters from the example which seems most applicable is not sufficiently correct for the purpose, the proper balance can be obtained by using the following simple method.

A series of exposure steps should be made[3] on the selected film with variable exposure to the high light illumination of the photo-

[3] Photomicrography, 14th ed., Eastman Kodak Company, Rochester, N.Y., 1944 (in press).

micrographic field. This is obtained with a transparent illumination by setting up the photomicrographic system and focusing as usual, then racking the subject out of the field, leaving the background clear but with the same focus; with reflected light, a piece of white paper can be substituted for the subject. One such series should be made with each proposed variation of the compensating filters. The correct filters will cause the steps to be gray, whereas an excess concentration of a given filter gives the gray a tinge of its hue. This is best judged in the middle tones. With the Retina or Bantam films, each frame must represent an exposure step. It is usually unnecessary to make a whole exposure series for each proposed filter but merely to obtain a medium gray density. With Kodachrome sheet film, the black paper separators which come in the boxes of film are very suitable for making a group of masks that will allow a series of individual exposure strips to be made along a single sheet. Six or seven strips can easily be placed on a 5 x 7 inch sheet. Each one represents a somewhat different illumination quality. The black paper will not fog the film as another paper might. The Kodachrome film must then be sent back for its usual processing.

Illumination

For most Kodachrome photomicrography, either the Type A or Type B film for artificial light is used.

In the preceding discussion, it has been assumed that the illumination would be correct at the lamp or be corrected to it by the proper photometric filter, except in the case of Method III, where that filter is deliberately used which makes the illumination correct on the ground glass rather than at the lamp. In low-power work and in many other types of photomicrography, this "correct" quality is sufficient and the process is simple.

For photomicrography with Type A Kodachrome, a very satisfactory method is to utilize the proper lamp for the film, i.e., the Photoflood, and convert it into an efficient source for photomicrography. Essentially, it consists in illuminating a sheet of ground glass from behind with a Photoflood lamp No. 1 or No. 2, and using a variable diaphragm directly in front of and against the ground glass so that its luminous surface, which is the effective light source, can be controlled in size down to a very small area. A condensing lens is then held in front of it to form a complete lamp. In practice, the lamp socket can be enclosed in a tin can or a fairly large fiber box. With a hole cut at the top over which is a second box with a hole in its back, there is good

ventilation with a light lock. A series of diaphragms can be made from black Bristol board or sheet metal, each piece containing a hole of different diameter; or a variable diaphragm can be made very easily from two pieces of sheet metal with horizontal V-notches cut in each to form a diamond-shaped aperture as they slide past each other. A resistance of 30-35 ohms in series with the lamp, which can be short-circuited through a switch during photographic exposure, will give the Photoflood lamp as long a life as the usual illuminants. Such a resistance is furnished by two 660-watt, 115-volt, radiant heater units in series.

The direct-current carbon arc is particularly suited to Kodachrome photomicrography in spite of the fact that its spectrum contains an excess of ultraviolet which must be eliminated. Except for studio lamps especially made for 3200°K., a tungsten filament lamp must be especially calibrated to obtain a specified color temperature at a proper current, whereas the same quality (color temperature) of illumination is obtained from a carbon arc lamp whenever the carbons, amperage, and voltage are the same, irrespective of the make of the lamp. The arc is somewhat susceptible to the rate of cooling of its environment and therefore to the extent to which it is enclosed and protected from drafts. This susceptibility decreases markedly, however, with increase of current density, i.e., with a high current relative to the size of the carbons. At a high current density, the pure carbon arc is exceedingly reproducible.[4] Moreover, there is considerably less variation of color temperature with variation of current in such a case and much less than when an ordinary incandescent tungsten filament lamp is used. Obviously, either of the two following procedures will achieve an increase in current density: increasing the current, as in going from the 5-ampere to the 10-ampere arc, with an 8-mm. positive carbon, or decreasing the size of the positive carbon electrode from the common 8-mm. to the 6-mm. carbon diameter. Both the Bausch and Lomb 10-ampere d.c. automatic arc using 8-mm. carbons and the 5-ampere d.c. arc using 6-mm. carbons (Zeiss Neophot) are very satisfactory.

The specification of the quality of illumination from the carbon arc for photographic use, particularly by color temperature, is not a simple matter, principally because the arc is not a homogeneous light source in the near ultraviolet and violet region. In Kodachrome photomicrography with a carbon arc, an ultraviolet-absorbing filter is usually used, such as a solution of sodium nitrite or a Wratten 2A filter. The latter also removes some of the far blue. With none of the available filters, however, can the illumination of the arc be made identical, both

[4] MacPherson, H. G., "The Carbon Arc as a Radiation Standard" J. Opt. Soc. Am., 30, 34, 189, 1940.

photographically and visually, with their color temperature values determined in the usual manner. The color temperatures of arc lamps, however, can be considered as approximately correct representations of the quality of the illumination as it affects Kodachrome Film, *independent of the ultraviolet and blue component of light* which is dependent upon the color filter in use. They are given, therefore, in Table II. The values in column 3 are measured from the image of the core of the anode as projected by an achromatic condenser.

TABLE II

Amperes	Anode Diameter in mm.	Visual Color in °K.
4½ d.c.	8	3645
5 d.c.	8	3680
5 d.c.	6	3750
10 d.c.	8	3820
10 a.c.	6.4-6.4	3475

In practice, the lack of accurate values for the color temperature of the arc lamps has proved to be unimportant since there are no photometric filters that are correspondingly accurate photographically for converting the arc quality to that required by the Kodachrome Film and, moreover, the presence of compensating color filters in the beam is so frequently required by independent considerations already discussed. The chief value of the arc lamp as a light source for photomicrography is the fact that its illumination quality can be reproduced so simply and well.

The color quality of the illuminants used for visual microscopy varies widely, and the habitual use, for this purpose, of one particular illuminant establishes the standard of color balance that is considered acceptable for colored photomicrographs. For instance, microscopists who are accustomed to using, for visual work, a high-intensity tungsten lamp with a relatively thick bluish "daylight" glass filter—and this apparently includes most medical men—consider the photomicrographs obtained with Kodachrome Film, Type A, and the carbon arc at 4.5 amperes with no ultraviolet or photometric filter to be satisfactory for color balance. Such pictures appear much too blue, however, to anyone accustomed to using a microscope with incandescent tungsten (2800°-3000°K.) light or even with actual daylight. The recommendations given here are based on the balance that produces the best neutral gray when the picture is projected or when it is viewed on an Eastman Kodachrome Illuminator.

According to this criterion, conversion filters composed of a 1-cm. layer of 3 per cent sodium nitrite plus an Eastman Color Compensating Filter CC14 give a satisfactory reproduction for Kodachrome Film, Type A, with a 5-ampere d.c. carbon arc. However, as discussed previously, the resultant Kodachrome photomicrographs, especially at relatively high powers, will also be influenced by the optics of the illumination system. In such a case, of course, the photometric filter (CC No. 14) must be modified or a compensating filter added.

The nitrite filter alone is probably sufficient for Type A Kodachrome Film with the 10-ampere a.c. arc.

For Professional Kodachrome Film, Type B, the color temperature of all the carbon arcs must be reduced, but the arc is also a very satisfactory illuminant for this film. The equivalent of a Wratten 2A filter is incorporated in the Wratten 86C filter (which otherwise has a little less than the correct photometric conversion power for use with the 4.5-ampere d.c. arc and this film) and causes the Kodachrome reproduction to be too yellow. On the other hand, the amber photometric Eastman Color Compensating Filters CC13 to CC15 transmit the near ultraviolet and should be used only in the presence of an ultraviolet-absorber, such as the nitrite or the dinitrobenzene filters. In practice, excellent reproduction is obtained with commercial optics, including an f.1 simple aspheric lamp condenser, if the optics in the microscope are good, when the following filter combination is used: a 3 per cent solution of sodium nitrite in a 1-cm. layer plus an Eastman Color Compensating Filter CC15 plus a 1-cm. cell of the liquid magenta compensating filter diluted from 35 cc. of working stock to 1 liter. This may be somewhat affected, of course, by the particular equipment used. If necessary, the balance can be altered either by Method I or by Method III, which alters the CC filter or the concentration of the magenta.

An objection to the use of the arc lamp for bright-field illumination is its high intensity. One method of overcoming this difficulty is to illuminate a piece of ground glass from behind, with the arc lamp, and then to use this glass as the light source, as was described for the Photoflood lamp, with the arc focused directly on the ground glass and the latter re-imaged with another condenser. In this case, it is important to interpose a water cell between the arc and the ground glass. With a crater image of ¼ inch in horizontal diameter and an f.1 condenser, the illumination is reduced about one hundred times; this reduction can be increased very easily to a factor of one thousand or more as the size of the primary crater image is increased. The greater scatter-

ing of short wave lengths by the ground glass causes the resultant illumination to be slightly yellower. The intensity may also be reduced by means of a suitable neutral density filter, but it must be remembered that not only are no perfect neutral densities available but the departure from neutrality may be different for a color film than for the eye, to which such filters are usually balanced.

Unfortunately, gelatin neutral filters of a sufficiently high density for this purpose cannot be recommended for use with an arc lamp. Waller and Breedis[5] have already pointed out that the Bausch and Lomb neutral density glass filters can be used in Kodachrome photomicrography, even though they do introduce color, if other filters that will compensate this are employed. A rather heavy density is required if very short exposure times are to be avoided in transmitted light with an arc lamp. However, a short exposure time is an advantage in photomicrography and a gear shutter is recommended for this work. The Bausch and Lomb neutral glass densities transmit near each end of the visual spectrum. Since the far red transmission is relatively unimportant, the result is that these "neutral" densities may act as a very blue filter to Kodachrome. This effect on the film, could of course be neutralized by a filter that absorbs blue, i.e., one with the correct amount of the complementary color, yellow, but it is preferable to accomplish this by absorbing the offending violet with a filter of sharper cut that transmits blue. This can be done by the proper thickness of the Corning Noviol "O" glass filter bound together with the "neutral" glass. A satisfactory and frequently easier method is to use the yellow liquid compensating filter (p. 147) in suitable concentration. Different melts of this glass vary in shade, and each individual worker will have to determine the exact compensation needed by making a series of exposure strips on a piece of film through several filter combinations (see page 150). Moreover, a slight magenta or green correction may have to be included. On the other hand, the compensating filters for a series of "neutral" glass filters from the same batch of glass will usually be consistent and strictly proportional to the neutral densities. As a rule, the secondary corrections can be neglected for the light densities.

Example: One density of 1.5 from a set of glass densities frequently sold for photomicrography merely required a very dilute magenta filter (1 cc. of the working stock magenta to 100 cc. water) to make it also an excellent neutral to Kodachrome. However, another glass filter of neutral shade from the same firm, with a density of 1.68, required

[5] Waller, R. K. and C. Breedis: "Photomicrography in Color", J. Biol. Phot. Assocn. *10*, 71 (Dec. 1941).

a filter of the yellow dinitrobenzene sulfonate (10 mm. of 20 cc./100 cc.) plus a magenta filter (2.5 cc./100 cc. of magenta working stock).

When such a filter* has been made up, however, the d.c. carbon arc becomes a most suitable source for Kodachrome photomicrography by transmitted light.

The incandescent tungsten filament lamp can also be used for Kodachrome photomicrography, and many excellent pictures have been made with the various types of lamps normally used in photomicrography, such as the ribbon filament. For many workers it represents the most convenient source, in spite of the fact, that it cannot be depended upon to reproduce the same color temperature from lamp to lamp even when burned at the same amperage, and that there is an appreciable change of quality with age. This is more serious where the illumination comes from a single lamp than in the studio where the illumination is an average of the quality of several lamps. Some means of determining the color of the individual lamp at the time of use is essential unless individually calibrated lamps can be obtained. A few workers in large institutions which contain a suitably equipped physics department may be able to obtain such lamps or have their own calibrated. Usually, one must depend upon a simplified instrument, the Eastman Color Temperature Meter, which is relatively easy to use and sufficiently accurate for most purposes. It measures the ratio of the red and green light in the illumination and is based on the assumption that the total spectrum is that of an incandescent black body. As we have seen, the illumination on the ground glass of a photomicrographic system may be very different from this quality so that the Color Temperature Meter should be used only to measure the direct light from the lamp.

By burning the tungsten lamps somewhat below their normal current rating and then raising the color temperature of the illumination to the desired level by always using the same relatively pale photometric filter with it, the trouble caused by the aging of the lamps can at least be much reduced. For instance, a Wratten 78C filter should be used with a ribbon filament lamp that is to be used with Kodachrome Type B Film. The simplest method is to adjust the current through the variable rheostat or transformer until the two fields of the Color Temperature Meter, set for 3200°K. are equal when the lamp is viewed through such a filter. The lamp will probably last for its normal life when used in this manner, especially if the current is decreased still

* During the present emergency it may be found possible to obtain the unpolished square pressed-glass blanks when the usual finished filter is unavailable. These blanks can then be polished flat on both sides by most optometrists.

further for visual work. An entirely new lamp should not be calibrated without some preliminary aging.

Illumination consisting of a mixture from several sources of different quality or that from a source with a discontinuous spectrum, as that from vapor lamps, is not suitable for color photography. This precludes the use of the relatively new tungsten arc, which is excellent for black-and-white work, because of the mercury vapor in its spectrum. However, quite satisfactory pictures on Kodachrome Type B Film can usually be obtained with this source by using a compensating filter combination of the Wratten No. 2A plus a Corning didymium glass filter, No. 5120, 2.0 mm. in thickness.

Synopsis. Different methods of photomicrographic exposure control are briefly described with references. A method of exposure control is mathematically and experimentally developed for standard exposure meters. A "Field Ratio" is developed which is the image diameter divided by the photoelectric cell diameter. This "Field Ratio" together with film speed modification factors, gives the same control of exposure in photomicrography that is available in ordinary camera work. The mathematical and experimental proof are developed to fit a practical method that has had several years of successful use.

Association Convention

The convention will be held September 7, 8, 9, at the Arlington Hotel, Binghamton, New York. This is the first time that the B.P.A. is meeting in Binghamton, the home of the second largest manufacturer of photographic materials. Binghamton is conveniently located on direct rail lines from all directions. The Erie and Delaware Lackawanna railroads connect with all other main roads, thus affording convenient transportation.

Ansco promises to demonstrate their color process, in order that everyone can see firsthand the simplicity of developing this new color material in his own darkroom. Also, a new color printing method will be described which permits the making of color prints directly from color transparencies in one exposure step. Another paper that will be of much interest will be presented by Dr. Bruce Buckler, Director of Visual Education of International Business Machines Corp., concerning modern technic in the preparation of visual aids. Special tours will be made through the Ansco plant. Ansco will sponsor a cocktail party and dinner, possibly at the beautiful Binghamton Country Club high on a hill overlooking the Triple Cities valley.

What a Medical Student Looks For in Teaching Films

Robert Mallory III, M. D.*

DURING the last two years of medical school, the clinical years, motion pictures are used to supplement the courses, and the results obtained in 1940-42, with the author's class, in Temple University Medical School were not what were desired. And so a group of students met and drew up a list of what were considered the basic requirements of medical films for teaching purposes, from the students' viewpoint, which, it was felt, had been neglected. And using this list as a guide, the author made several films which were judged as meeting the requirements, and it is the point of this paper to state the faults found in the films and how they were overcome.

1. It was clear from the start that black and white films were of no value because it was impossible for the average student, unless well grounded in photography, to comprehend the difference between nerves, blood vessels, muscles, and fibrous tissue. This was overcome by using color film, Kodachrome.

2. Students lost interest in a film when the scenes jiggled. This difficulty was solved by using a steady tripod, the Eastman Cine-Kodak Tripod, with the Cine-Special with 200 foot chamber and a special heavy lens mount, figures 1 and 2.

3. The majority of the films showed only the major steps of an operation, omitting the minor steps upon which these were based, and the scenes were too short. The method used to combat this fault was to use plenty of film, letting the student-photographer be the judge of what was necessary and what was not, and then when the doctor gave the word to stop, running a few frames extra, as generally doctors do not know how long it takes a student to absorb a scene. This resulted in the films usually being longer than planned, but the results obtained warranted it.

4. Most of the films also lacked adequate close-ups. Those shown included too much confusion of instruments around the edge of the

* Alden Park Manor, Philadelphia, Pa. Presented at the Thirteenth Annual Convention of the Biological Photographic Association, September 12, 1943 at Princeton, New Jersey. Received for publication March 3, 1944.

wound or incision. This was overcome by doing the majority of photographic work from 8 to 12 feet with a special 6½ inch f.3.0 Hugo Meyer Trioplan lens, which is shown on the camera with the special heavy lens mount in figure 1. This also permitted the photographer to remain outside the sterile field, an asset from the patient's viewpoint. An f.3.5 12 inch lens, figure 2, was kept on hand for use, if necessary, for ultra-close-ups.

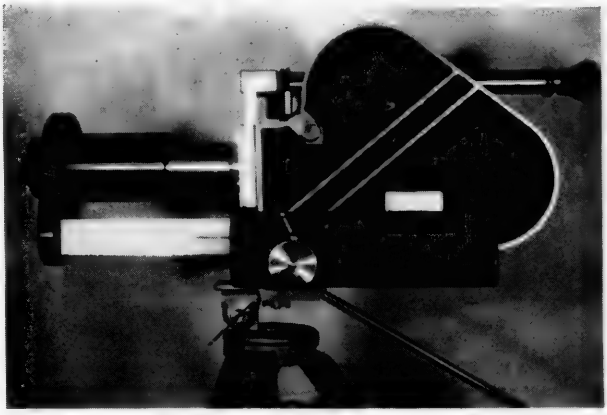

Figure 1

5. In almost all surgical films the surgeon worked so fast that the students were unable to see clearly just what was being done. This factor was corrected by taking the films at 24 frames per second and projecting them at 16 frames per second. This slowed down the action sufficiently to enable the students to follow what was going on, and yet it was not slow enough to appear as slow motion in any degree.

6. Another criticism was that in the majority of the films there were long titles explaining what was to occur or what had been left out. This was remedied by photographing the the minor steps and using only short titles directly to the point, and these only when absolutely necessary. But two titles were added, one at the beginning giving the pre-operative history of the case,

Figure 2

and the other at the end giving the outcome, because these points are necessary to show the student why the operation was performed and what might be expected to be achieved by the surgery.

7. When an actual scene could not be photographed, the films viewed used animated drawings to show the action. This failed to give the correct impression of the action to the students because it was only in two dimensions. Hence models were used when this type of work was necessitated, and the consensus of opinion was that this method was much better.

8. In several cases the films were shown to fill in time and/or in addition to the regular work. The result was that often these films did not teach the students very much because there was a failure to have them well organized in the course, whereas if they had been shown at another time, they would have been more beneficial. It was found that when the professor had viewed the film previously, he could, and usually did, use it advantageously in his course.

All these standards and methods of achieving them add up to just one word and three people. The word is cooperation, and the three people involved are the doctor, the photographer, and the student. The three must work in the closest cooperation to obtain the best result. It is the belief of the author that the best results are obtainable if the photographer and student are combined in one, as then he not only knows what he wishes to see on the screen but also how it may be obtained from the photographic viewpoint and what problems he must surmount to prevent harm to the patient (i.e.—camera too close to the patient is within the sterile field or hinders the action of the surgeon).

Some Aspects of Photomicrography

by Albert Sadler*

It is possible that many medical photographers whose duties include Photomicrography, are interested in the methods used by other workers. Others may be interested in a non-technical paper. Most of the articles on the subject are written by optical experts, and unless one is also something of an expert, the meaning of the article may be partly lost. Very few articles appear which are practical working descriptions of technic, based on personal experience. With this in mind, some of the following observations are to be regarded as my personal opinion, based on practice. This is a summary of my own methods, coupled with the rules of photomicrography which apply to all of us. It also bears upon different equipment which can be used.

This article is written in the hope that others, especially those undertaking photomicrography without much experience, will benefit. It is not intended to be authoritative, but merely a guide. As the title implies, it does not cover the entire field, but what it does cover is, I think, such part of the subject that the medical photographer usually has to apply to his work. For more detailed technical data, one should read "Photomicrography", published by Eastman Kodak.

To begin this article, for the benefit of the few who do not know, I would like to differentiate between Photomicrography, and Microphotography. So many people use the latter term when they mean the former. At the Convention in New York City in 1942, there was a spirited discussion as to the meaning of the two words, when one speaker attempted to prove, by means of diagrams and Greek, that microphotography actually meant photography through the microscope. Up to the time of writing, such photography is correctly described by the word photomicrography, and until such time that it is changed we will continue to use that term.

Micrography is the graphic description or drawing of an object of microscopic size, therefore the prefix "photo" makes the description a photographic one. A photomicrograph is a photograph of a minute object as seen through the microscope.

Microphotography has an opposite meaning. A microphotograph

* Eloise Hospital. Eloise. Michigan. Received for publication December 20, 1943.

is a photograph of microscopic size, just as a micro-organism is an organism of microscopic size. There being a limit to which a negative or positive can be reduced, the term has come to mean a photograph of extremely small size, which requires a magnifying glass in order to study it.

APPARATUS

The equipment used by the writer is a Bausch and Lomb optical bench, consisting of Type R camera with 5 x 7 back, microscope, and illumination assembly. Generally speaking, one should use a wide barrel microscope, a camera of sufficient bellows extension, and a lamp with condenser and diaphragm. An assortment of oculars and objectives are required. It is important that the combination of the two lenses match, that is if apochromats are employed, the oculars should be of the compensating type, while for acromats, the oculars should be standard. The best results are undoubtedly obtained with apochromatic objectives, but excellent work can be done with achromats, other things being equal.

The substage condenser employed here is the one made by Bausch and Lomb for this particular microscope. It is an achromat and has a numerical aperture of 1.40 and a focal length of 9.2 mm. The N.A. of the substage condenser should never be less than the N.A. of the highest ocular used. If it were less, the rear element of the objective could not be filled with light, and this in turn would cause imperfect illumination, poor resolution, and so ruin the photograph.

The light source consists of a 6 volt ribbon filament projection bulb, with a transformer to step down the voltage from 110v. to 6v. It is ideal for photomicrography, and preferable too, for the light is even and constant, and one bulb will last about a year. A carbon arc light source is often used on more complicated optical benches. Of the two, the ribbon filament bulb gives off less heat. Both require compensating filters for Kodachrome, and for black and white film, the filter factors are much higher for the carbon arc. The Mazda T20 coil filament lamp has a color temperature of 3200 degrees Kelvin, and is correct for Kodachrome Type B.

An adjustable condenser and iris diaphragm are used in front of the light source. This is absolutely imperative when the Köhler system of illumination is employed. The entire assembly should be rigid and mounted upon a solid foundation. The use of a sponge rubber mat

between the optical bench and its support will be found to be of great value, particularly when there is vibration of the building from traffic.

MAGNIFICATION

It is important that some sound method of calculating the magnification for the equipment used, is available. The standard formula, with a tube length of 160mm and bellows extension of ten inches is:

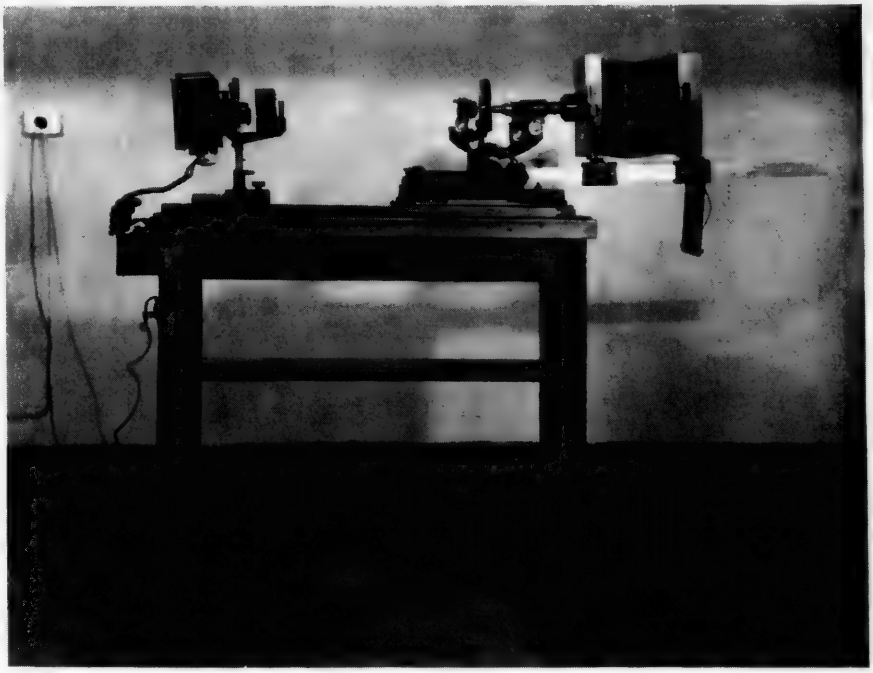

Figure 1. Bausch and Lomb optical bench used by the author.

tube length divided by aperture of objective (in mm) multiplied by power of ocular. Some objectives are marked by a number indicating their power, and when this is multiplied by the power of the ocular, the magnification is arrived at, this being correct for a ten inch bellows extension. We therefore can call the latter a unit (1) or $\frac{}{10}$, and any variation in this distance may be written in terms of 1, e.g. a 12 inch extension would be $\frac{12}{10}$, a five inch extension $\frac{5}{10}$, and so on. When using a small camera, the film can never be ten inches from the ocular if the entire field is to be included, therefore the magnification of the

image on the negative must be worked out correctly, and subsequent enlargement to 5 x 7 used to bring the image to a practical size, care also being taken to note the times of enlargement (linear). When this is multiplied by the magnification of the negative image, the final figure will be correct. The equation to be used therefore, is,

$$\frac{\text{Tube length (mm)} \times \text{ocular} \times \text{extension (ins)}}{\text{Aperture of objective} \qquad 10}$$

$$\text{e.g. } \frac{160 \times 10}{4} \times \frac{10}{10} \text{ equals } 400$$

If a 35mm camera is employed it would be

$$\frac{160 \times 10}{4} \times \frac{2}{10} \text{ equals } 80$$

A five times linear enlargement of the 35mm negative on a 5 x 7 print would bring the magnification up to ×400, equal to that of a 5 x 7 negative obtained at ten inches extension.

The power employed should always be governed by the subject being photographed, never by any set standard combination of ocular and objective. For this reason, bellows extension is extremely important, as also are three oculars, ×5, ×10, ×15, and a set of objectives, 16mm, 8mm, 4mm, 3mm oil, and 2mm oil. With such an assortment, any intermediate magnification between ×50 and ×2000 may be obtained. Bellows extension should never be used to excess. When a magnification is reached which can be had with a ten inch extension and next higher ocular, or next higher objective and lower ocular, the bellows draw should be reduced and higher lenses used. This is because a long draw, while giving the magnification, will not give the definition that the higher lens combination will give. It is a good policy therefore, to never allow the bellows draw to exceed 15 inches.

Adjustment of the Apparatus

Two types of illumination are in use today. (1) Critical, and (2) Köhler. Critical illumination requires that the image of the light source be focused in the plane of the specimen. If the image is not large enough to cover the field, an enlarged image may be obtained by the use of a lens placed between the light and the microscope. The substage condenser diaphragm is then focused in the plane of the specimen, and opened up until it just cuts the edge of the field. This controls the area of illumination.

Köhler illumination requires that the image of the light source be focussed upon the substage condenser. It is usual to bring the image

to a sharp focus on the closed substage iris diaphragm. The condenser is then racked until the image of the lamp diaphragm is focussed in the plane of the specimen. The advantage of the Köhler method is in its control of both the area and aperture of illumination. The subsequent remarks on adjustment refer only to the Köhler method.

Before attempting any real work, the entire system must be lined up. The light source must be placed a sufficient distance from the microscope so that its image is large enough to fill the substage condenser. Remove all lenses from the system except the lamp condenser. Insert the pin-hole eyepiece and close both the substage and field diaphragms. Focus the light source, by means of the lamp condenser, upon the substage iris. When one looks through the pin hole eyepiece, the two closed diaphragms should be concentric. If they are not, adjust the substage mirror, (in the case of a vertical assembly) or in the case of a horizontal assembly, loosen the clamps about the microscope base and shift the microscope until it is in line. Tighten the clamps well, Another method is to take a piece of thread and tie a bit of match stick to each end, threading it through the barrel, substage, and lamp diaphragms. When held taut, it should pass exactly through the centre of the entire system. This is not quite as accurate as the first method, but when a pin-hole eyepiece is not available, it is the next best.

Figure 2. Brain Syphilis. H and E stain. B and G filters. Ortho plate. ×190.

Having aligned the system, one is ready to adjust the optical assembly. First of all, the substage condenser must be centered. This is done by inserting all the lenses and focussing the objective on a slide, then bringing the closed field diaphragm into focus by means of the substage condenser. The centering device on the objective must be removed. The condenser may now be centered by twisting the small screws on either side of it until the small circle of light is brought to the exact center of the field, or better still, have the camera in position and center the disc upon the ground glass. Now replace the centering collar of the objective. Center the objective in the same manner as the condenser,

using the two screws which fit over the two square projections from the collar of the objective. If a standard microscope is used, with no provision for adjustment of the objectives, the substage condenser should be centered through each objective separately as they are used, so that any deviation on the part of the objective will be compensated by the condenser. This is not the perfect set up, but it is a happy substitute.

In using dry objectives, the top element of the substage condenser must be removed, in order to increase the focal length of the condenser, and to lower its numerical aperture. This is necessitated by the larger microscopic field. Centering adjustments with dry lenses should be made with the top condenser element removed, since there may be a slight difference compared to the element in place. Adjustment with oil immersion objectives should be made with the top element in place.

PHOTOGRAPHING THE SPECIMEN

Insert the slide in the mechanical stage. The field to be photographed is either ringed or has ink dots placed on either side. If the pathologist has time, it is a good idea for him to be present in order to select the exact field. This will eliminate retakes when the photographer has not placed the subject properly. A fair knowledge of pathology and histology will prove to be of great value in photomicrography.

Insert the ocular and objective for low power ($\times 100$), set the bellows draw at ten inches, and focus the microscope. Having found the field to be photographed, remove the slide and clean off the ink spots with a piece of cotton and a drop of 1% hydrochloric acid. The slide must be clean and free from film and dust if a good picture is to be made. This is extremely important. Re-insert the slide. If the stage has not been moved, the area to be photographed will lie in the microscopic field. If a higher power is required, change the lenses to the proper combination, and focus. For high power work, it is much easier to find the field with low power and then change the lenses, than to search for it under high power. If an oil immersion objective is employed, replace the top element of the substage condenser, and place cedar oil between the condenser and the under surface of the slide, and of course between the objective and cover slip. Check the substage condenser focus. Slides sometimes vary in thickness, requiring condenser adjustment because the condenser is focussing the field diaphragm in the plane of the specimen. It is very important also, to check the centering of the objective and condenser, because they are subject to vibration and handling, and consequently can move slightly. Unless lenses are centered, and both condensers correctly focussed, the illumination will

be uneven. The centering is best checked by closing the field diaphragm. Its image should fall upon the x mark in the center of the ground glass. If it is off a little, adjust the objective.

The field diaphragm should now be opened until it just cuts the edge of the microscopic field. This diaphragm controls the area of illumination. If the bellows are drawn out beyond ten inches, the entire field will be too large for the ground glass, that is it will extend beyond the edges of the short side. In this case, the diaphragm should be closed until its image is entirely visible, in order to illuminate the field only. In any case, the circular image should almost touch the side edges of the ground glass. The substage diaphragm should be closed until it cuts the edge of the field, or, if the diaphragm image is not sharply visible, until the fringe of light beyond the edge of the field is eliminated. This diaphragm controls the aperture of illumination. It is of vital importance that only the area to be photographed is illuminated. Illumination of a larger area will result in scattered light and some diffusion, causing the negative to lose brilliance and contrast. If the substage diaphragm is not closed far enough, the image will flatten out and be of poor contrast, and if it is closed too far, refraction of the image will result. Generally speaking, this diaphragm should be open to about the diameter of a lead pencil with a 16mm. objective, twice as much for an 8mm., and four times as much for a 4mm. objective. For oil immersion lenses, the diaphragm cuts the field when it is about two third open, depending on the focal length of the objective. If these settings are kept constant for each objective, calculation of the exposure will be made much more accurately.

Figure 3. Spirochetes in primary chandre. Modified Levaditi stain. H filter. Ortho plate. ×*1350.*

Dark Field and Pola Screens

Most medical photomicrographs are made using bright field illumination, but occasionally one is required to use other types. In photographing unstained spirochetes or nematodes, a black background brings

them out clearly, and this is achieved by either a dark field condenser, or dark field stops.† No light must be transmitted directly from the condenser to the objective, hence the light must be blocked off. At the same time the specimen must be illuminated by transmitted light. Because such specimens will refract light, a beam from below at an oblique angle will be refracted into the objective. The lower lens of the dark field condenser is therefore covered with black lacquer, except for a narrow rim. This condenser projects light through the specimen at such an angle that it forms an inverted cone around the objective, with its apex at the field. For low power dark field work, the stops supplied with the microscope should be used.

After focusing the objective and condenser, the stop is inserted in the slot below the substage diaphragm. Select a stop that is a little smaller than the diameter of the diaphragm opening. It may be necessary to adjust both condenser and diaphragm slightly for perfect illumination. The exposure will be about the same as for bright field. Dark field illumination with immersion and high power objectives requires the use of the dark field condenser. The top element must have a drop of immersion oil connecting it to the slide, and the slide must be of the correct thickness as designated by the condenser manufacturer. If good results are to be obtained, slides and cover slips must be absolutely clean and free from scratches, since such defects would appear as bright spots or streaks on the dark ground.

Centering the condenser must be done after the specimen has been brought into focus. If the condenser has no adjustment, the centering screws of the objective should be turned until the illumination is central.

The use of Pola screens requires nothing more than inserting them above and below the specimen. These screens for use with the microscope are supplied in the form of an eyepiece and a substage slide. Make all adjustments as for bright field, then insert the Pola screen in the slot below the substage diaphragm, and place the eyepiece screen over the ocular. By rotating the eyepiece, the correct degree of polarization may be obtained. The lower screen may also be placed in the filter slot in front of the light source. Regular filters are not used in conjunction with the Pola screen, since the object is to define foreign bodies such as crystals, etc., in tissue, or chemical crystals of known variety in suspension or dry smear. The crystals stand out as luminous bodies while the tissue or background appears very dark. Exposure is extremely long, about two or three minutes for a power of $\times 100$, to twenty minutes or so for magnification of $\times 450$. Exposure is best de-

† Frontispiece: *J. Biol. Photo. Assn.*, 12:46. Dec. 1943.

termined by making a series of exposures on one film, as one would make a test strip in enlarging.

Filters

A good set of filters is absolutely necessary for photomicrography. They may be liquid, gelatin bound in glass, or glass. With most set-ups, some method of cooling the light beam before it reaches the substage condenser, is necessary in order to eliminate the possibility of softening up the lens cement, with consequent damage, and also to protect the filters. Heat absorbing glass is satisfactory, if you happen to have it, for it is difficult to obtain at this time. A water cell of clear fault-free glass, at least two inches in width, is suitable, and it may be filled with 10% potassium alum or plain water. This water cell is rectangular and is made to fit certain illumination assemblies.

If the lamp is one requiring a flask of water in front, the flask may serve the double purpose of cooler and filter by use of the Zetnow liquid filters. Two or three flasks are needed for different colors, since one filter is insufficient. These filters are in yellow, orange, green, and blue, and are made from solutions of potassium bi-chromate and copper sulphate. The formulae may be obtained by writing to the Eastman Kodak Co. (Medical Division). When using liquid filters or a water cell, care must be taken to remove the condensation of water which is produced while the liquid is becoming warm.

Figure 4. Foreign body granuloma (experimental) (H and E stain) Magnesium silicate crystals photographed by polarized light. Ortho plate. ×300.

The best set of filters available for photomicrography is the Wratten "M", comprising nine filters as follows. A25 (red), B58 (green), C547 (blue), D35 (purple), E22 (orange), F29 (red), G 15 (deep yellow), H 45 (blue), and X1 11 (light green).

Filters serve two purposes. They affect contrast, either by increasing or decreasing it, and they narrow the wave length of the illumination to a comparatively narrow band. This narrow band markedly increases the definition in the negative, since different colors have different wave lengths, and do not come into focus in the same plane,

whereas when the image is rendered monochromatic or nearly so by the filter or filters, it will focus critically in one plane. Therefore, even if an unstained preparation is being photographed, a filter, preferably green, should be used.

Most stained preparations require filters which will increase the contrast either slightly or considerably. Varying factors are the thickness of the tissue, nature of the tissue, type of stain, intensity of the stain, and power of the magnification. Another factor is, of course, the type of emulsion used but this is usually a fixed factor since most workers stick to one kind of film for this work. Most of the slides for photomicrography are stained with haematoxylin and eosin, the tissue cells being light to dark blue, and the other tissue pink to red. Red and blue are complementary colors, and photographic emulsions are quite sensitive to blue light, therefore a filter combination must be used which will strengthen both. For this purpose, the B (green) and G (deep yellow) combination giving a yellow green screen will be found to give the best results. If the slide has high contrast, the G filter alone will suffice, and it will usually do for powers in excess of $\times 400$. This filter combination has a factor of 12 for commercial orthochromatic plates, and slightly more for panchromatic, to tungsten light; and for a power of $\times 100$, the exposure is two or three seconds.

When other two color stains are used, one color must be strengthened, or one weakened, or both. It is usual to strengthen the nuclear stain, and the rule applied is that a filter of a color complementary to that stain will increase the contrast, and one of the same color as the stain will decrease the contrast. When a stain is more or less of one color, such as metallic impregnations or simple stains, the same rule applies.

Emulsions, Exposures, and Development

With the proper filters, a commercial orthochromatic plate is quite suitable for photomicrography. Before the war, Panatomic X was widely used, and that emulsion is available now on glass plates. The Wratten "M" plate is also available. The choice of emulsion depends a great deal on preference and what one has been using and has mastered. It may depend at times on what is available. If faster films have to be used, the neutral density filters should be employed to make the exposure long enough to count, and development should be in a high contrast developer. Better results are always obtained by using a very slow emulsion, because of the greater resolution. Ortho versus Pan, plate versus film, is strictly a matter of choice. Plates are heavy, require more storage space and are breakable, but they do lie flat, and this is very important when the exposure is being made. They do not

stretch or shrink, and if separations are made they are indispensable. Having used plates for some time, I advise their use. Panchromatic film has less resolution than orthochromatic, but not enough to be noticeable to the naked eye. It cannot be developed by inspection as well as ortho. It must be loaded into the holders in total darkness, and if plates are used, one sometimes does not know on which side lies the emulsion. A Series 2 safelight and ortho plates make loading easy, rapid, and errorless. A plate exposed through the back means unnecessary work. For these reasons, orthochromatic plates are preferable.

Eastman Kodak now advocates the use of either Contrast Process Ortho A.H. or Contrast Process Pan A.H. cut film for photomicrography. These films have very good contrast and resolution. With the correct exposure and correct development particularly, they will yield excellent results, but extreme care must be taken in exposing and processing because of their narrow exposure latitude, and rapid development.

The criterion for a good negative is, full exposure and normal development. Underexposure will ruin it, and so will overdeveloping. Overexposure and/or underdevelopment will yield a negative too flat for useful purposes. The negative gamma should be such that it will yield an excellent full scale print on a number 2 contact paper. A long scale is needed, and it will not be obtained on a hard paper, in spite of the fact that some people think that a photomicrograph should always be printed on a hard paper in order to obtain plenty of contrast.

In making the exposure, the light should be on, and a black card interposed in the light beam just below the microscope. Remove the dark slide and lift the card for the required number of seconds, then lower the card and replace the dark slide. If a camera having a shutter is used, (don't forget to remove the lens), the shutter should be left open and exposure made by means of the card. With 35mm cameras having a focal plane shutter, the shutter must necessarily be closed to protect the film from fogging, but if the collar attachment between camera and microscope is light locked, the exposure should be made by holding the card across the light beam, opening the shutter, lifting the card, lowering the card, and finally closing the shutter. If the camera is not physically connected to the microscope, an extension tube wide enough to clear the ocular, with a heavy piece of black cloth wrapped around both will suffice, provided that no light can get by. All photomicrographic work is best done in a darkened room, the less light the better. The camera shutter should never be used in making the exposure, since most of them will set up a slight vibration or jar, and spoil many negatives. This is particularly true with focal plane shutters.

Films should be developed in either DK 50 or D 11, depending on personal preference, and contrast required. Miniature films will yield good negatives in D 76 if the exposure is a full one. Time of tank development at 65 degrees F is 5 minutes in D 11 and 7 minutes in DK 50. For process film, either ortho or pan, tank development should be 5 minutes in DK 50 diluted 1 to 1, at 65 degrees F. This will yield a gamma of approximately 2.0. If the developer is undiluted, the gamma will be 3.0.

With a 5 x 7 negative, the circular image will be about 4¾ inches in diameter. A contact print is made using a circular mask 4½ inches in diameter between the two emulsions. This sets off the print against a pure white border. If smaller negatives are used, the image may be projected onto the 5 x 7 paper having a 4½ inch mask in front, covered by a sheet of clean glass. This will achieve the same result. When a rectangular print is required, it means either extending the camera bellows without stopping down the field diaphragm beyond the edge of the microscopic field, or enlarging a rectangular section of the circular negative. Since microscopic fields are circular however, it seems better to make a negative and print of almost the entire field and retain the circle. The subject should fill the field.

When making large prints for exhibition, etc., the mask is placed in contact with the negative. The projected image will then be a perfect circle. No matter what size negative is used, a mask of proper size will result in a circular print on a white border. The alternate method of cutting a circular mask to the size of the required print, and placing it in contact with the paper under a sheet of glass is also satisfactory. This will ensure that a series of prints are of equal diameter.

In conclusion, I would add that much practice, diligence, and patience are required in the making of good photomicrographs. All lenses and filters must be kept perfectly clean. A permanent optical bench, even though "home made", will be a distinct advantage, saving much time in setting one up when work has to be done. Don't change emulsions, but select one and stick to it. Technical factors must be standardized in order to avoid guess work and retakes. In focussing, the center of the field should be sharp. A cover slip cemented to the center of the ground glass will aid in obtaining sharp focus. The use of a magnifying glass is of value if this respect too, particularly if the ground glass is removed and the aerial image picked up. Another point sometimes overlooked, is that tobacco smoke will produce a definite haze in the light beam and result in inferior definition and contrast, so don't smoke when doing this work.

Exposure Control in Photomicrography

by John A. Maurer*

MANY different methods have been proposed in the past for the control or judging of exposure in photomicrography. The purpose of this article is to discuss these methods and to present a method of exposure control which uses standard exposure meters. It is applicable to most problems in brightfield photomicrography. In this method the variables will be the same as or similar to those of ordinary camera work. By use of a photoelectric meter, the light measurement is direct. A relationship between measured light and film plane illumination is developed using the "Field Ratio". Multiplying factors are given to modify published film speeds when using the usual photoelectric exposure meters for photomicrography. The calculator dial of the exposure meter is used in essentially normal fashion. Without trial exposures, but after measuring the diameter of the image circle at the film plane, it should be possible to obtain the exposure directly. Accuracy of exposure should be similar to that in ordinary camera work.

The various methods of exposure control is photomicrography may be divided into the following groups:

A. Exposure is determined by simple trial and error, generally by a series of exposures on one negative. In photographic enlarging a comparable method is the exposure test strip. [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11]

* From the Photographic Department, Loyola University School of Medicine, Chicago, Illinois. Received for publication March 22, 1944.

[1] "Effective Light Sources in Photomicrography." D. H. Hamly. Amer. Ann. of Photo. 1943, p. 38.

[2] "Photomicrography by the Finlay Process." Jean Kieffer. Journ. Biol. Photo. Assn. 2:178, 1934.

[3] "Technique of Photomicrography." John King. Amer. Ann. of Photo. 1935, p. 214.

[4] "Judging Kodachrome Exposure in Cine-Micrography." Blaisdell Kull. Photo. Tech. p. 24, June 1939.

[5] "Kodachrome Photomicrography by Transmitted Light." Anonymous. Radiol. & Clinical Photo. 18, p. 12, 1942.

[6] "Routine Record Photomicrography." Herbert C. McKay. Journ. Biol. Photo. Assn. 4:86: 1935.

[7] "Photomicrography for Everyone." Herbert C. McKay. Amer. Photo. 31:786, Nov. 1937.

[8] "Practical Photomicrography." Powell & St. Clair. Photo. Tech. p. 6, Dec. 1939.

[9] "A Simple & Flexible Apparatus for Tachygraphic Cinephotomicrography." Oscar W. Richards. Journ. Biol. Photo. Assn. 3:64:1934.

[10] "Photomicrography with the Lumiere Color Process." Frances Carter Wood. Journ. Biol. Photo. Assn. Vol. 3:169:1935.

[11] "Handbook of Photomicrography." Hind & Randles, 1913, 1927, 1935. E. P. Dutton & Co., N. Y. & George Routledge & Son Ltd., London.

B. A known good exposure is used to calculate the new exposure. This method is given in several sources, among them Hind and Randles [11], and the Eastman book Photomicrography. [12, 13, 4, 5, 6, 14, 9, 15]

C. The light intensity is measured at the film plane. There are two general methods for making this measurement. One method is to use an extinction meter on the ground glass [15, 9], and the other is to use a photoelectric cell on the ground glass. [9, 15, 16, 17, 18, 19, 2, 20, 21, 22, 25] If the photoelectric cell method is used on negatives 3¼ x 4¼ or larger, it may be necessary to have a very sensitive cell and galvanometer, or else to use an electron tube amplifier. Especially with the photoelectric method, very precise calculation is possible.

D. Based on past experience, the exposure is judged by the brightness of the ground glass. As a special variation the intensity of illumination is controlled so that to the eye the ground glass intensity is a constant. This may be done in three ways: a) a Rheostat on an incandescent light[1]. b) Mechanical control of light volume by varying the distance between the primary source of light and a light diffusing screen[1]. c) By control of the size of the microscope condenser aperture. This method should only be used to a limited extent, if at all, because it also changes the resolving power.

E. A photoelectric cell or exposure meter measures all the light emitted from the ocular of the microscope. The bellows length is kept constant, (fixed distance between film plane and microscope). [16, 8, 23] This is a special variation of the next method.

F. A photoelectric cell (or visual extinction meter[24]) measures all light emitted from the ocular. This light flux is correlated with any and all distances between ocular and the film plane. This method is

[12] "Photomicrography." Anonymous. A book published every few years with revisions. Eastman Kodak Co.

[13] "Kodachrome Exposure with the Microscope." George H. Needham. Camera Craft. 47:397, Aug. 1940.

[14] "Handbook of Chemical Microscopy." Vol. I. Chamot & Mason. 1930. John Wiley & Sons Inc., N. Y. & Chapman & Hall Ltd., London.

[15] "Versatile Photomicrographic Unit." Bishop & Downing. Photo. Tech. p. 48; Aug. 1940.

[16] "Using Exposure Meter in Photomicrography." Walter E. Burton. Photo. Tech. p. 50, Aug. 1941.

[17] "A Simple Photoelectric Exposure Meter for Use in Photomicrography." Wilton R. Earle. Journ. Biol. Photo. Assn. 7:54:1938.

[18] "A Photoelectric Exposure Meter for Photomicrography." Gross & Johnson. Journ. Biol. Photo. Assn. 1:172:1933.

[19] "A Method for Determining Exposure for Photomicrography." Hefley & Smith. Journ. Biol. Photo. Assn. 10:165:1942.

[20] "Experience in Kodachrome Photomicrography." S. I. Kornhauser. Journ. Biol. Photo. Assn. 12:47:1943.

[21] "Determination of Exposure for Kodachrome Photomicrography." Thomas H. Morton. Photo Tech. p. 50, Dec. 1941.

[22] "Color Photomicrography of Biological Specimens." Royer & Wissemann. Journ. Biol. Photo. Assn. 8:115:1940.

[23] "Determining Exposure Time of Photomicrographs with the Instoscope Exposure Meter." John H. Graff. Journ. Biol. Photo. Assn. 6:161:1938.

[24] "Clinical Cinemicroscopy." Richard B. Stout. Journ. Biol. Photo. Assn. 1:18:1932.

[25] "Photometric Units and Nomenclature." E. B. Rosa. Sci. Papers U. S. Bur. of Stand. 6;543:1910.

developed here for the usual type of photoelectric exposure meter. The mathematical basis is also developed for those who wish a more rigorous proof. An article on this method but without the mathematical proof of the exact relationships was submitted by the writer to Bausch & Lomb Optical Company in April 1938. A report of the basic method was made to the BPA in a short impromptu talk at the convention in Buffalo, in September 1941. Apparently from this report, Eastman have very nicely described this method and applied it in particular to the control of exposure of Kodachrome film[5]. It was independently developed by Graff and reported in June 1938 for use with the visual extinction type of exposure meter. [24] Graff also mentions the use of a photoelectric meter for this purpose, but apparently the meter he used was not sensitive enough for this method. There are reports though of the use of standard photoelectric exposure meters to collect the total light from the ocular and apparently all had enough light for satisfactory readings. [5, 8, 16, 23]

G. Other or individual methods[13].

All of the above methods have and do produce successful results. Some methods are easier to use than others.

Theoretical and Experimental Proof

Since 1937 the author has been using the Weston Photronic exposure meter for calculating photomicrographic exposures. It has been at least as accurate as most other methods, and is easy to use. The meter is held an inch or so away from the ocular so that all the light from the eyepiece is collected by the photoelectric cell. The exact distance does not matter if the circle of light is within the area of the cell and not smaller than about ½ inch in diameter for the Weston meter. The circle of light may fairly well fill the width of the cell on the G.E. meter. In this manner the largest possible reading may be obtained, for any particular magnification and combination of adjustments, of the actual light that is projected onto the film plane.

A relationship must be found between the meter light reading and intensity of light at the film plane. In order to use the calculator on the meter as "Pseudo f.No."* was developed. If the diameter of the circle of light at the film plane is eight times the diameter of the cell of the exposure meter, this ratio is called "Field Ratio 8." By the use of such a "Field Ratio" the measure of the light at the film plane will vary at the same rate as the light at the film of a camera will vary with the f. No. opening used on the regular camera lens. The differ-

*In 1940 the term "Pseudo No" was discussed with Adrian Ter Louw of Eastman Kodak Co. He felt that one should be very careful to note the difference between a camera lens f/No and the "Pseudo f/No" for photomicrography. Accordingly perhaps the term "Field Ratio" is more appropriate.

ence in exposure needed between f. 1 and f. 8 in either usage is 8^2 or 64 to 1. The same number of lumens of light will be present on the film plane as were found at the meter except that the intensity will be 1/64th as great and the needed exposure 64 times as great.

The exposure meter measures all light coming from the eyepiece. This light reading is used on the calculator. The f. No. to be used on the calculator is the "Field Ratio" which is the diameter of the image circle at the film plane (or ground glass) divided by the diameter of the active area of the photoelectric cell. The cell diameter of the

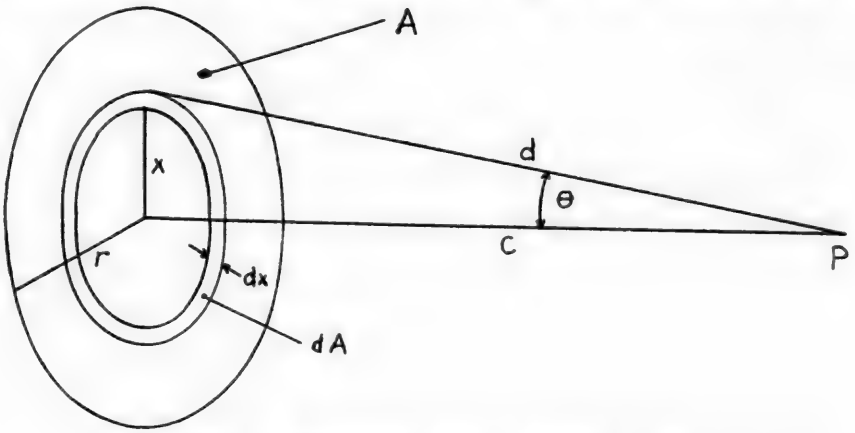

*Figure 1. Illumination from a circular disc.**

Weston exposure meter is 4 cm. For other meters where the cell is not circular, the area of the cell can be calculated and from this may be obtained the diameter of a circle of equal area. The G.E. meter cell is equivalent to a cell 3 cm. in diameter. It remains then to obtain the correlation factor for film speed. This factor adjusts for the difference in illumination at the film plane of the camera versus the film plane of the photomicrographic apparatus when the light reading of the meter is the same for both cases. To develop this factor rigorously and practically is an important part of this article. The problem was investigated by a) Investigating the theoretical and actual response of the meter. b) Using equipment capable of reading illumination at the ground glass of photomicrographic apparatus. c) Correlating exposure meter response for camera and photomicrographic equipment. d) Calculating film speed modification factors for photomicrography for a variety of exposing and developing conditions. In the photographic sense of exposure latitude, for the special case of a meter whose ac-

*Adapted from Illumination Engineering by Wm. E. Schilling. By permission of International Textbook Co.

ceptance angle is 60°, and for average work it is not greatly different from 1. This means that but little or no correction in film speed should be made for photomicrography when using the calculator in the normal manner.

An exposure meter of the usual type has been designed not to read incident light, but rather to read average brightness of the area outlined by the meter's angle of light acceptance. The fact that an exposure meter is an object brightness instrument is well shown when using a meter such as the Weston Master (model 715). The low brightness range of this instrument has an acceptance angle of 60°, while the high brightness range has an acceptance angle of 30°. In such a case when the *entire light source is of small extent,* then the narrow acceptance angle (high range) will actually give a higher indicated reading than will the larger acceptance angle (low range). This is the normal and proper action of a brightness meter. Specifically for the 715, if the low range is used on a light bulb and a reading of 50 is obtained, then the high range will read 100.

Let us now consider some of the mathematics involved. The first relationship will be that of image-object brightness in ordinary camera work. This is adapted from Goodwin's analysis of the basis of the Weston meter[30].

Let $E_{n\text{-}\theta^\circ}$ = Foot candles of incident light on film plane.
B = Object brightness in candles per square foot.
T = Light transmission of lens.
F = Distance between lens and image (focal length of lens for distant objects).
d = Diameter of lens.
θ = Angle between the optical axis and any particular image point in the film plane.

Then

$$E_{n\text{-}\theta^\circ} = \frac{B\,T\,\pi\,\cos^4\theta}{4(F/d)^2} \text{ foot candles} \qquad 1.$$

As an average it is assumed that

$\theta = 16°$ or $\cos\theta = .96126$ and $\cos^4\theta = .8532$
$T = .70$ $\quad F/d = f$ = lens f/No.

$$E_{n\text{-}16^\circ} = \frac{.4688\,B}{f^2} \text{ foot candles.} \qquad 1a.$$

Or on the lens axis

$$E_{n\text{-}0^\circ} = \frac{.55\,B}{f^2} \text{ foot candles} \qquad 1.b$$

[30] "Kodak Reference Handbook." Eastman Kodak Co.

The second relationship to be shown is that between the brightness of an evenly illuminated disc, a point at the center directly opposite the disc and the reading of an exposure meter at that point. This is the equation of light flux available to operate the photoelectric exposure meter. This equation can also be used to calculate the light flux from a surface of great and indefinite extent. As shown by and adapted from Rosa, Schilling and others [26, 27, 28] in figure 1, a circular disc has a radius r and a brightness B. The illumination at P is Ep and the vertical distance from P to the disc is c.

Ep is obtained by integration of the equation of illumination from zero to the angle Θ. Θ is the angle between the axial line c and the periphery of the disc.

$$\text{If } dEp = \frac{B\, dA\, \text{Cos}^2\, \Theta}{d^2}$$

It may be shown that (28)

$$Ep = \pi\, B\, \text{Sin}^2\, \Theta \Big]_{O}^{\Theta}$$

But since $\text{Sin}\, \Theta^0$ is zero, we may consider the formula to be

$$Ep = \pi\, B\, \text{Sin}^2\, \Theta \qquad 2.$$

From this integration formula can be determined the light flux effective in readings for incident light meters, and by limiting the angle, for brightness meters. For incident light meters, the plane is of indefinite extent and

Θ is 90° or $\text{Sin}\Theta$ is 1.

$$E_{90°} = \pi B = 3.14\ B. \qquad 2a.$$

For the brightness meter of 60° acceptance, $\Theta = 30°$

$$E_{30°} = .25\pi B = .785\ B. \qquad 2b.$$

For the brightness meter of 30° acceptance, $\Theta = 15°$

$$E_{15°} = .0671\pi B = .2105\ B. \qquad 2c.$$

Equation 2b was used with a light source of even brightness and limited extent. The calibrated foot candle meter was used with this source in such tests as would change it to be also a brightness meter with an accuracy of about plus or minus 5%.

[26] "Light, Photometry and Illumination." 2nd Ed. Wm. E. Barrows. 1938. McGraw-Hill Book Co.
[27] "Illumination Engineering." Wm. E. Schilling. 1st Ed. 1940. International Textbook Co. Scranton.
[28] "Exposure Meter Manual." General Electric Co.
[31] "Weston Exposure Ratings, What They Are and How They Are Determined." W. N. Goodwin Jr. Amer. Photo. 32:548. August. 1938.
[32] "Exposure Determination in Photomicrography." L. G. Henbest. Journ. Biol. Photo. Assn. 3:2:1934.

The reading E, of an incident light meter will be foot candles or lumens per square foot of light incident at the meter. In the case of the brightness meter though, the reading B, is the brightness of the source of light in candles per square foot. The Weston Photronic exposure meter reads directly the average brightness B of an object in candles per square foot. With one exception it does not read incident light in foot candles. The special exception is for the embossed lens 60° acceptance type of Weston Photronic meter. In this case, *for axial light only,* the reading as accurately as the meter can be read, seems to be foot candles of incident light. This seems to be a special case for the particular device used to limit the angle of light effective on the meter. Table I shows what may be expected of this special case. The G.E. exposure meter with the limiting shield removed is basically an incident light meter and reads in foot candles of incident light. With the shield on, the meter is a brightness instrument although it does not read dircetly in candles per square foot. The calculator and the G.E. film speed make the proper calculation[29].

TABLE I

Response of Weston Photronic Exposure Meter to axial light. Low range only of Model 715.*

Model 715	Calibrated Ft. Cdl. Meter
50	45
25	25
13	13
6.5	6.5
3.2	3.1
1.6	1.64

*Checking the high intensity range of this meter shows that for axial light it reads twice the value of the incident light in foot candles.

The writer wished to be sure that the accuracy of the experimental part of this article was at least better than the practical accuracy to be expected in general photographic practice. For this purpose an extra sensitive photoelectric outfit consisting of a Type 3 Weston Photronic RR cell, portable taut suspension mirror galvanometer and an adjustable universal shunt was especially calibrated at the light laboratories

[29] "The Photronic Exposure Meter." W. N. Goodwin Jr. Journ. Soc. Mot. Pic. Eng. 20:99:1933.

of Lewis Institute of Illinois Institute of Technology. For this the writer is greatly indebted to Messrs. Harrington, Sanborn and Larson for permission to use a laboratory standard lamp and photometric bar equipment. The equipment was calibrated to be both an incident light or foot candle meter and a brightness or candles per square foot of object meter. The accuracy of the incident light meter so calibrated is about plus or minus 3%. The accuracy of the brightness meter is about plus or minus 5%. By means of this equipment the Weston 715 meter was recalibrated. The greatest error was 1/3 of a stop which is Weston's tolerance of accuracy. Most reading showed the meter accuracy to be better than 1/6th of a stop, which is the factory inspection tolerance.

With this calibrated equipment the Weston 715 gave the results shown in Table II. Slight pivot friction makes the 0.4 and 0.2 readings of this 715 meter slightly doubtful.

TABLE II

Response of Weston Photronic Exposure Meter Model 715, No. 1977463 to source of known brightness B.

Low Range				High Range			
B	715	B	715	B	715	B	715
50	55	6.5	6	1000	950	80	72
40	45	4.0	4.5	800	725	50	40
32	36	2.0	2.0	650	550	40	36
				500	400	32	28
25	27	1.3	1.3				
20	21	.65	.6	400	350	25	25
16	16	.4	.4?	250	200		
13	13.5	.2	.2?	200	160		
10	10			130	115		

In Table III are shown the actual foot candles on the film plane with an object brightness of 1000 candles per square foot. The lens used here was checked for physical optical dimensions. Marking errors at f. 22 and f. 32 were greater than 1/6th stop and were remarked. For our purpose, the light source used could be satisfactorily considered to follow Lambert's cosine law of light emission from a diffuse source. Compared with these indicated values of film plane foot candles, are the theoretical calculations and the readings of the 715 meter. The accuracy of these readings is not as good as the photometric bar work in calibrating the reference meter.

TABLE III

Film Plane Illumination with an Object Brightness of 1000 Candles per Square Foot.*

Working f. No.	715** Meter	Indicated Ft. Cdls.	Calculated Grd. Glass Foot Candles (15) Average 16° .47 B/f²	On Axis .55 B/f²
6.3	13	12.5	11.83	13.86
8.0	10	9.7	7.33	8.59
11.3	4	4.05	3.78	4.32
16	2.4	2.2	1.835	2.15
22.6	1.	.90	.920	1.077
32	.5	.43	.458	.5375

* Object brightness at end of readings was 900.

** Column 2 readings all finished before starting 3.

We can now apply the mathematical formulas and experimental results to the case of exposure control in photomicrography. The basic formula for average illumination in the film plane as presented by Goodwin is;[30]

$$E_{n\text{-}16^\circ} = .4688\ B/f^2 \qquad 1a.$$

And as shown by Rosa, Schilling and others the illumination incident on an exposure meter of 60° acceptance is;[26, 27, 28]

$$E_{60^\circ} = \pi\ B\ \sin^2 30^\circ = .785\ B \qquad 2\ \&\ 2b.$$

But for the low range of the 715 Weston as shown by Table I, the reading for axial light is practically the same as foot candles of incident light.

$$E_{axial}\ (\text{Weston}) = \text{foot candles incident.} \qquad 3.$$

As the meter will be used to collect light for calculating photomicrographic exposure using the "Field Ratio" = f, the Goodwin formula can be modified to;

$$E_{micro} = E_{axial}/f^2 \qquad 4.$$

And the ratio of exposure, will be the ratio of the E's;

$$E_{axial}/E_{n\text{-}16^\circ} = 1.00/.4688 = 2.13 \qquad 5.$$

Which is the ratio of film plane illuminations for the same Weston Exposure meter readings in photomicrography vs. view camera work according to the theory and testing just presented.

PRACTICAL CONSIDERATIONS

It would appear then, if the Weston film speed ratings were doubled for photomicrographic work, the Weston Exposure meter can be used

directly on the low scale reading for control of photomicrographic exposure. In actual practice though, there are three more factors that further modify our hypothetical case. The first factor is the distribution of light and shade in the microscopic image. The second factor is the selection of the desired density to be controlled. The third factor is the desired degree of development.

The balance of light and dark areas and the range of subject brightness is considerably different in microscopic material from that of the type of subject on which an exposure meter is normally used. The average transparent type of tissue slide photographed through the microscope may have large areas of white. Considerable parts of the light portions of the stained tissues will be in the highlight range as compared to average camera scenes. In general the dark areas, which are the parts taking a nuclear stain, do not need a heavy exposure. Gradation of detail in these blacks is not needed. The stray or non-image forming light may be expected to be somewhat greater in a microscope image than in the image formed by many good camera lenses. This would indicate that for the photomicrographic work a practical control of exposure is the method of controlling the high light density of the negative. To do so, the light should be read in a clear area of the slide. The exposure is then set to give the desired density in the negative for the white or highlight area. If the light is read separately from both the clear area and a stained area, a common ratio for such as an H & E stain is as 3 is to 2. In the case of copies of photographs, the ratio given for film speeds indicates that white reflects four times the light of the average photographic print.[30] This ratio or slightly more is sometimes indicated for white card readings in average scenes[31]. Thus we can see that the microscope image quality is different from that of the normal photographic subject. For our practical needs, with normal development, it will be assumed that highlight brightness of the subject is four times that of the average scene for average camera work. This means that the light value to control our exposures is four times the value at which the arrow on the Weston exposure meter calculator is to be set in the usual or common use of the meter.

If it is desirable to keep the highlight density fairly constant, then when developing to a lesser gamma (shorter development) the base exposure will have to be increased. On the other hand when developing to a higher gamma, the exposure would have to be reduced. In calculating the film speed modifying factors to be given, it has been assumed that the classical type of emulsion is used wherein the inertia

does not change with the degree of development. This is not always true. Past experience in adjusting exposure and development for any particular film should be useful. Contrast control by use of the usual photomicrographic color filters is of course to be used as much as practical. In many cases for the average H & E stained material one can use a variety of green filters. In such cases the Wratten filters X1, B2, B2 & H and then G & H generally act as a series of filters of increasing contrast. Any effect is apparent visually. The allowance for filter factor should be made after calculating the white light exposure.

Specific Directions

Adjust the photomicrographic apparatus so that in every respect the image quality is the best obtainable. Select the contrast filter to be used but remove before making the light reading. Color compensating filters for direct color films such as Ansco Color Film or Kodachrome are not removed in reading the exposure light. The contrast filter factor for exposure in black and white work is applied after the white light reading.

Move the microscope slide so that either only stained tissue is visible in the microscope or only a clear area.

Place the exposure meter a short distance from the eyepiece of the microscope. See that all of the light falls on the photoelectric cell. It does not have to fill the whole cells but should cover an area greater than one fourth inch in diameter.

The light reading obtained is to be used as directed on the calculator.

In place of the camera lens f. No., use the "Field Ratio" which is the diameter of the full image circle at the film plane divided by the diameter of the photoelectric cell. When the meter is used at the film plane (no ground glass intervening) the "Field Ratio" is f = 1. The Weston cell is 4 cm in diameter and the G.E. cell is equivalent to 3 cm in diameter.

Figure your exposure using the modified film speed rating. Multiply this exposure by the contrast filter factor.

Return the microscope slide to its proper position. Place the proper filter in the light beam. Expose the film.

Film Speed Modification Factors

The modification factors are given with the assumption that normal development recommended for the film will be used. It is also assumed

that your meter is reading correctly. The directions for variation from normal development will be given later.

For Western Photronic Meters
60° Acceptance Angle.

a) Measure the light through a clear area and use this value directly at the arrow or normal exposure indicator on the calculator. The film speed to correspond is half the published speed. Thus if the film has a rated speed of 24, use a speed of 12.

b) Measure the light through the subject in the type of subject that generally reads 2/3rds the reading through a clear area. Use this value for the usual normal light value to be used at the arrow or normal exposure indicator. The film speed to correspond is 80% of the published speed. Thus if the film has a rated speed of 24, use a speed of 20. At "Field Ratio" f = 1, the result is for ground glass exposure. This is identical with the Hefley and Smith exposure table. Remove the ground glass when making the reading or find the allowance for the presence of a ground glass.

On the high (30°) range, readings are relatively twice those on the low (60°). Divide by 2 to make equivalent to low (60°) range readings.

For General Electric Meters

For the General Electric exposure meters a few facts should first be reviewed. As a foot candle meter, the reading from a point source of light is directly given in foot candles. It does not matter whether the shield is used or not, as for a properly oriented meter, the shield has no shielding effect on a point source of light. When making readings from a microscope eyepiece it is not necessarily advisable to use the multiplier cover. When placing the meter near the eyepiece of a microscope the smaller area of a G.E. meter would theoretically give a reading 1.77 times that of a Weston meter used on the low range. The G.E. meter here used was checked on the calibrated foot candle meter. It was as accurate as the pointer could be read. Actually by trial comparison of a G.E. meter and a Weston meter on a microscope, the ratio was 1.5x. The G.E. meter is also equal to a cell 3 cm. in diameter while the Weston is 4 cm. in diameter. The early type of G.E. meter is of course read at the usual indicator point. For later meters with the three indicator positions of Cover Closed, Cover Open and Incident Light; the calculator is to be used at Cover Open position for all readings below 70.

Assuming now that conditions similar to those for the Weston meter are to be used with the G.E. meter we find the following results. The film speeds referred to are G.E. Speeds, the "Field Ratios" those for a G.E. meter, and the light values those read on a G.E. meter with the shield off. Normal development recommended for the film is assumed.

a) Measure the light through a clear area and use this value directly. Use 40% of the published film speed. Thus if the film has a rated speed of 40, use a speed of 16.

b) Measure the light through the subject (2/3 of clear area reading) and use this light value directly. Use two thirds (2/3) of the published film speed. Thus for a film of G.E. Speed 40, use speed 24 instead.

Development Contrast and Exposure

When the development is to twice normal contrast, expose one half as long as for normal development. When the film inertia changes much with development, the exposure change needed will be larger. A trial may be needed for the particular development and film used.

When developing to half normal contrast, expose twice as long as for normal development. When the film inertia changes much with development, the exposure change needed will be larger. A trial may be needed for the particular development and film used.

Special Subjects

Light delicate material, such as blood or bone marrow smears are often so much in the delicate highlight range that extra care must be taken. In such cases it may be advisable to give two thirds or half the exposure that would otherwise seem correct.

For dense material, such as ground sections of bone, the clear area will transmit much more light than the bone. In such cases try 4, 8 and 16 times the exposure calculated from the clear area. Examine the results to see which is the best. After that, when bone sections have been prepared to have the same opacity to light, use the increased exposure factor which your trial indicated as best.

This method of exposure control should be useful for some types of metallurgical specimens.

For darkfield illumination, certainly with most subjects, it will not be possible to estimate exposure with this method.

Acknowledgment: For kindness in individually reviewing this article or the offering of various useful suggestions thanks are due to the following people: Miss Avis Gregersen, Mr. J. W. Crunelle, Mr. James Glaze, and Dr. M. Massler of the Chicago Chapter; Mr. Lorenz of Bausch and Lomb Optical Co.; Mr. Miller of Western Electrical Instrument Co.; engineers of General Electric Co., meter dept.; Mr. Adrian Ter Louw and Mr. R. P. Loveland of Eastman Kodak Co.; and Mr. Lloyd Varden of Ansco.

BOOK REVIEW

MEDICAL PHYSICS, edited by Otto Glasser, Ph.D. Published by The Year Book Publishers, Inc., 304 South Dearborn St., Chicago, Illinois. 1794 pages, 7⅜ x 10½ inches, and 1382 illustrations, cloth bound, $18.00.

After seeing this excellent volume, medical physics takes on an entirely new meaning. The text of this book brings to the reader a wealth of material presented in useful form, which should be of direct interest to all those engaged in various fields related to physics in medicine. This encyclopedia, textbook and working instrument contains 255 articles written by notable and authoritative scientists. The 23 classified tables of contents correlate all the articles which should be of essential aid to the Anatomist, Bacteriologist, Biologist, Biophysicist, Dermatologist, Hematologist, Internist, Medical Photographer, Neurologist, Ophthatmologist, Orthopedist, Otolaryngologist, Pathologist, Pediatrician, Physical Chemist, Physical Therapist, Physicist, Physiologist, Radiologist, Surgeon, Urologist.

Of special interest to the biologic photographer is the chapter on medical photography, which is a fairly complete resume of the developments in the field.

Included in this volume is a subject and name index, a list of abbreviations and symbols and a comprehensive cross reference to other articles.

Editor.

QUARTERLY SUPPLEMENT NO. 18 for the Photo-Lab-Index. "A Guide to the Literature of Photography and Related Subjects. Compiled by Albert Boni. Published by Morgan and Lester, 101 Park Avenue, New York. 94 pages. No illustrations.

To use the author's words " . . . this is a preliminary step toward a much expanded **Index to the Literature of Photography** . . . The final work is expected to cover five times the material surveyed in the present publication."

The author is to be commended for starting such an ambitious project. There is a definite need among professional, research, and serious minded amateur photographers for a work of this kind. It is to be hoped that Mr. Boni will receive every assistance necessary to enable him to complete his final book.

May we suggest a little more care in proofreading? On page 94, "California and the West" listing, the co-authors are given as Charles Wilson Weston and Edward Weston. Mr. Weston's co-author, and charming wife's name is Charis, not Charles.

Ray Meiss.

Fourth Detachment, Museum and Med. Arts Service—Army Medical Museum Somewhere in Australia.
Standing, left to right: Sgt. Walter K. Shaw, Cpl. Henry C. Johnson, Sgt. Raymond L. Howard, Pfc. Frederick C. Dick.
Seated, left to right: Tech. Sgt. Edgar J. Nebel, 1st Lt. William J. Taylor, Sgt. Daniel P. Balkin.

TENTH REPORT OF THE COMMITTEE ON MOTION PICTURES, 1943.

I. *Films reported by our members.*

L. V. Bergman: Ovulation and the effects of the gonadotropic hormone from pregnant mare's serum (sound speed in color); Normal and abnormal dentition (mostly animation).

C. L. Claff: Phenomenon of excystment of Colpoda cucullus.

E. J. Farris: Tropical opossums (Kodachrome, 16 mm., silent, 400′); Biology of reproduction in rats (ditto).

J. Felsen: Hand to mouth. (16 mm., 2 reels, Public Health Film).

L. Gibson: Surgical treatment of post-phlebitic ulcer (16 mm., 400′).

A. Hancock: Transfusion of blood and technic of freezing, drying and injection of concentrated plasma via the bone marrow. (Kodachrome, 16 mm., 700′).

F. R. Harding: Premature infant care (16 mm., 500′); Kenny method, 2 films on* (Kodachrome, 16 mm., silent).

F. W. Kent: Technique of transurethral surgery (Color, 16 mm.).

H. C. Knight: Primary syphilis; Secondary syphilis; Tertiary cutaneous syphilis (16 mm., 400′ each).

M. W. LaRue: Inguinal hernia; Dermatitis in dogs—fungoid origin; Manual rotation in management of occiput posterior and occiput posterior positions; Conservation of syringes and needles; Continuous caudal analgesia in obstetrics; Analysis of function of clinical thermometer (all color, 16 mm., silent).

W. C. Lown: Arthroplasty of the hip (color and black & white, 1200′); Amputations, two (color 500′).

R. Mallory III: Demonstration of the heart-lung experiment (450′); Traumatic surgery (250′); Minor surgery of junior year (650′); Deliveries, as seen by a junior student (350′); Demonstration of the Bell-Magendie law (250′); An experiment on micturition (250′); Abdominoperineal proctosigmoidectomy (1200′); Preparation for delivery (black and white, 350′); Retinal detachment operation (350′); Cataract operations (350′); Elliott trephine operation (350′); Decomposition and extraction of a breech (500′); color, 16 mm., silent except as marked.

A. Pijper: Vi-agglutination of typhoid bacilli; Action of bacteriophage on typhoid bacteria; Motility of various microörganisms (darkfield, sunlight, 16 mm., 900′ each); Growth of yeast (250′).

A. Sadler: Music therapy* (Black & White, 16 mm., silent, 400′).

For information write directly to member listed. *Not available to others.

II. *Items of current interest.*

Nature reports that Mr. M. Michaelis, 51 Fitzjohn's Ave., London N.W. 3 is secretary of the British Scientific Film Association and that contacts are being extended to Scotland.

The history of the laboratory and personnel of the United States Department of Agriculture Motion Pictures are summarized in *Business Screen Magazine,* 1943; 5:19-21, 32-33. Since 1918 over 700 motion picture films have been made.

Texas Med. Jour., 1943-44, 39:419, Additional films, motion picture lending library. (From Cur. List Med. Lit., 1944, 6:64).

Dr. H. E. Morton, Chairman, Committee on Materials for Visual Instruction in Microbiology, Dept. of Bacteriology, Univ. of Pennsylvania Medical School, Philadelphia, announces in the April *News Letter* of the Society of American Bacteriologists that they will sell abstracts of the films reviewed by them at 3c each (10c minimum). They have 90 films listed in this field.

Biological Abstracts are now publishing film abstracts under the heading "Visual instruction in microbiology, immunology and public health."

III. *Catalogs.*

Rutgers Films, Department of Biophotography, Rutgers University, New Burnswick, N. J. List No. 5. Films on biology, surgery and psychology.

The Wistar Institute, Philadelphia, has published "Approved Motion Picture Films" which lists 39 films in biology and medicine.

IV. *Publications of interest.*

Berhard, F., Recent motion picture films in physical education. *J. Hlth. Phy. Ed.,* 1943, 14:31-3.

Earle, W. R., Production of malignancy in vitro. II. Photomocrographic equipment. *J. Nat'l. Cancer Inst.,* 1943, 4:135-145. III. Microcinematographic equipment. *Ibid,* 147-164.

Emmett, H., Cinemicrography in scientific research. *J. Roy. Microsc, Soc.,* 1943, 63:26-33.

Lucas, F. F., Motion-picture study of Balata and Hevea Latices. *Ind. & Eng. Chem.,* 1942, 34:1371-1381.

Pack, G. T., and K. D. Swartzel, Jr., Stereoscopic photography for surgical motion pictures. Am. J. Surg., 1943, 61:215-223.

Lester V. Bergman,
Oscar W. Richards, Chairman,
19 Doat St., Buffalo 11, N.Y.

Association News

CHAPTER NEWS

Two chapters have survived the stress of war days, the Chicago and the Pittsburgh. The Chicago Chapter met every month throughout the winter. Its programs featured the following subjects: enlarging and print quality; 2 x inch lantern slides in black-and-white; the use of exposure meters in photomicrography; the uses of 35 mm. film in medical photography; bird photography by remote control; motion picture technic, etc. Some of these programs took the form of practical demonstrations. In addition to its regular meetings, the Chapter again put on an exhibit for the fall meeting of Ophthalmologists and Otolaryngologists. Some of the work in this exhibit came from our national Salon, but much of it was contributed by the Chicago members. We are indebted to the Secretary, Miss Avis Gregersen, for news of this Chapter's activities.

The Pittsburgh Chapter pared down its programs to four this winter. Two of them were on natural history, with photography of birds and flowers. A third included a discussion of the new Ansco Color processes. And the last contained a demonstration of a simple method of making photomicrographs in color with a hand-camera, and the G.E. film on photoflash bulbs. Since losing their Chairman, Mr. Levin, to the Army this Chapter has not held formal elections. The meetings have been called by the Secretary, Miss Anne Shiras, whenever worthwhile program material could be found.

FROM "MOVIE MAKERS"

In reviewing the best films of the year, picked by the Amateur Cinema League out of a large number of films submitted, the ACL's Journal "Movie Makers" for December, 1943, has this to say of Dr. Robert Mallory's film "Decomposition and Extraction of a Breach":

"The value of this type of cinematography to surgeons who work alone in small communities is incalculable. When it exists at all, it is highly serviceable; when it is as well done as Dr. Mallory has done it, it is a very high contribution to the art of healing."

Those who attended our Princeton Convention will remember Dr. Mallory's talk on motion pictures from the medical student's point of view, and the films which illustrated it. The ACL review goes on to

commend his use of models to show the misplacement of the child and some of the delivery technic.

PROMOTION

It was pleasant to receive a letter from our former Director, Lieut. C. Graham Eddy, who took the first unit of the Museum and Medical Arts Service to "somewhere in India", and to see by the return address that he is now *Captain* Eddy.

B.P.A. PROJECTS AND SERVICES

Please read the following outline of Association activities with an eye to what they offer you and an eye to what you can contribute to them. This two-way circulation of ideas is the essence of co-operative growth.

The Journal

Articles—Many of the papers we publish naturally deal with the latest applications of photography to scientific problems. But we also want articles that throw new light on old methods. A time-saver, a trick-of-the-trade, a gadget, a new angle, may be helpful to more readers than the latest bulletin for experimental outposts. Watch yourself as you go about your routine and see if there aren't things you now do by second nature which you once evolved by painstaking trial-and-error. If so, make that experimenting count for more by passing it on to others. Even if your method calls for only a paragraph or two, write it up for the Journal. A page of information for contributors and subscribers appears at the back of each issue.

If writing for publication congeals you, as it does many people, write your idea completely informally. Simply put it in the form of a letter and send it to *Mr. Ferdinand Harding, The Children's Hospital, Boston (15) Mass.* Mr. Harding, our present President, has been one of our most constant Journal contributors. He has written a number of his own original methods for us and will gladly write up yours if he finds them appropriate for the Journal, giving you complete credit for the idea of course. Don't forget that in the case of a particular set-up or gadget, a photograph or working-drawing, or both, will help clarify your description.

Back Numbers—A few of our back numbers of the Journal are missing, but on the whole we still have a good stock of past issues. We prefer to furnish these in entire Volumes or sets of Volumes. However, we have a few miscellaneous numbers which can be fur-

nished individually. The cost of back numbers to B.P.A. members is 50c per issue for numbers in Volumes III-XII; $1.00 for numbers in Volumes I and II. The cost to non-members is 75c per issue for numbers in Volumes III-XII; $1.25 for numbers in Volumes I and II. *Mr. Louis Schmidt, Rockefeller Institute for Medical Research, New York (21) N.Y.* is in charge of back numbers. He will gladly fill your order or give you information about available issues.

The back numbers we most want are:

Vol. IV, No. 2
Vol. V, No. 1, No. 3
Vol. VI, No. 3, No. 4
Vol. VIII, No. 2

If members have copies of these numbers they do not need, or know where they can obtain these numbers from former members we will gladly buy them back at 50c per number. We are very much in need of them to fill orders from libraries, etc. for complete sets.

The Journal has been microfilmed from Vols. I through VIII. Microfilmed positives of articles, or enlarged photostat copies can be obtained by writing the Secretary, *Miss Anne Shiras, University Office, Magee Hospital, Pittsburgh (13) Pa.*

Information about Journal Material—The Secretary has abstracts of Journal articles filed chronologically and also according to subject matter. If you need information about material which has appeared in our Journal she will be glad to send it to you.

Annual Convention

The B.P.A. holds a three-day meeting each year at which the year's advances in photography are discussed, as well as fundamental technics. At this gathering the photographer can talk over his problems with colleagues in the same field. He can discuss his equipment, etc. with the representatives of the firms that manufactured it. And he has the stimulus of hearing new work and new possibilities described by fellow-workers and of checking his experiences with theirs. No other meeting in the world offers a similar program planned especially for the scientific photographer and the photographically minded scientist.

At present we are going ahead with plans for the 1944 meeting. The possibility of holding this meeting, however, and its time and place depend so much on future conditions that we must keep our plans flexible. As we go to press, a meeting in the east during the first half of September seems most likely. We continue to choose eastern

meeting places because they entail less travel for the majority. When the renewal notices go out in early June more up-to-date announcements about the Convention will be made in them. Meanwhile, please let us hear any ideas you may have for program material, etc. All letters about the program, requests for information, etc. may be sent to the Secretary.

Salons

Annual Salon—Each year a new exhibit of pictures is shown at our annual Convention. Members are cordially invited to submit their work for exhibit in this Salon. It offers the scientific photographer an opportunity to show his work with that of his colleagues, and to have it seen by workers in the same and allied fields. Entry blanks will be sent to each member during the summer. It is important that these blanks be filled in, and that the specifications listed on the blanks be followed. The Salon Chairman is *Mr. Nathan Horton, 32nd floor, 22 E. 40th Street, New York (16) N.Y.*

Unless specifically instructed otherwise by the exhibitor, the B.P.A. retains all prints accepted for the annual Salon and incorporates them in the yearly Traveling Salon. This collection of prints is available to members for showing at scientific meetings and institutions throughout the year, at a cost of transportation one way. By circulating the Salon in this way it is seen by a much larger and more varied group than a single showing at the Convention could achieve. *Mr. Louis Schmidt, Rockefeller Institute for Medical Research, New York (21) N.Y.* is in charge of the Traveling Salon.

Albums

We have four albums in circulation at present. One, contributed by Mr. Louis Schmidt and Mr. Joseph Haulenbeek, shows the photographic methods developed at the Rockefeller Institute for Medical Research and the results obtained with them. It covers photography of gross specimens, clinical pictures, photomicrography and photomacrography, photography of culture and colonies, glassware, equipment, etc. Mr. Julian Carlile's album is devoted almost exclusively to the photography of plant photography at the Rockefeller Institute for Plant and Animal Research. However, his information on lighting, shadowless backgrounds, etc. is applicable to many other fields. A third album is compiled of several members' work. It shows various lightings for gross specimens, from raw to completely diffused light; examples of clinical photography and some work in photomicrography. The fourth

album contains recent reprints from our own and other Journals. Most of these have to do with medical photography (clinical and gross photography, photomicrography, copy, etc.) because that field seems to produce more articles on photography than the other sciences.

None of the above albums are new but the fundamentals contained in them are as valuable as ever. The transfer of many members to the armed forces and the pressure of work on others has naturally interrupted our production of albums. One book compiled by Mr. Wilbour C. Lown of the Massachusetts General Hospital was recalled by him for additions. Before it could be returned, however, Mr. Lown went into the Navy so that particular book is out for the duration. A valuable album on eye-photography, contributed by Mr. A. Marfaing of Columbia University was sent by request to a member who, in spite of repeated letters, has failed to return it. We regret that this loss has prevented other members from benefiting by Mr. Marfaing's authoritative and helpful book.

Although not strictly an Album, we must mention an excellent new collection of pictures sent us by a South American member, Mrs. Leopoldina Grabherr, Instituto Bacteriologico de Chile, Santiago, de Chile. Mrs. Grabherr has included a set of follow-up pictures of plastic operations and a series of photomicrographs. As her titles are in Spanish and full information about lighting, etc. is lacking, her pictures constitute an exhibit rather than an album. But enough information is included to show that the work was done almost exclusively with a miniature camera. The fine, spotless enlargements in their uniform and attractive mounting should be of great interest to any photographer, but particularly to those who have had experience with small cameras. These pictures will be displayed at our 1944 Salon. Meanwhile they are available to members who would like to study them.

Requests for them, and for the albums mentioned above should be sent to the Secretary.

The B.P.A. would welcome new albums and we urge our members to consider whether they could not compile their own work or collaborate with other workers to produce information and illustrations that would be useful to other workers.

Help with Problems

Members who want advice on various methods of biological photography may obtain help by writing other members; or by writing the Secretary who will refer their letters to the members most experienced in that field.

The Secretary has lists of members filed alphabetically and geographically; and also according to specific interests, range of work, etc. If you are looking for other members working on your same problems she can help you to find them.

Publicity

From time to time you may be approached for information about the B.P.A. by writers or editors of various publications. The Association naturally wants everyone who would find membership useful to learn of our existence. But we have many scientific members and any information released about those members must conform with the ethical standards of their professions. For this reason we earnestly request that any information you give out which concerns specific members and their work be first submitted for approval to our Chairman of Public Relations, *Dr. Arthur W. Proetz, 1010 Beaumont Building, St. Louis (8) Missouri.*

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Some individuals who have a deep interest in the advance of scientific photography help finance a wider range of activities for the Association by becoming Sustaining Members. The privileges of Regular and Sustaining members are the same. Either type may be chosen each July when the dues are payable.

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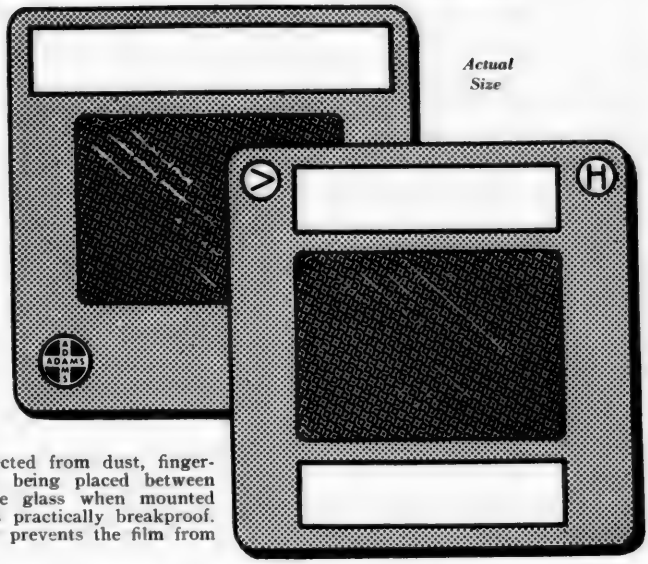

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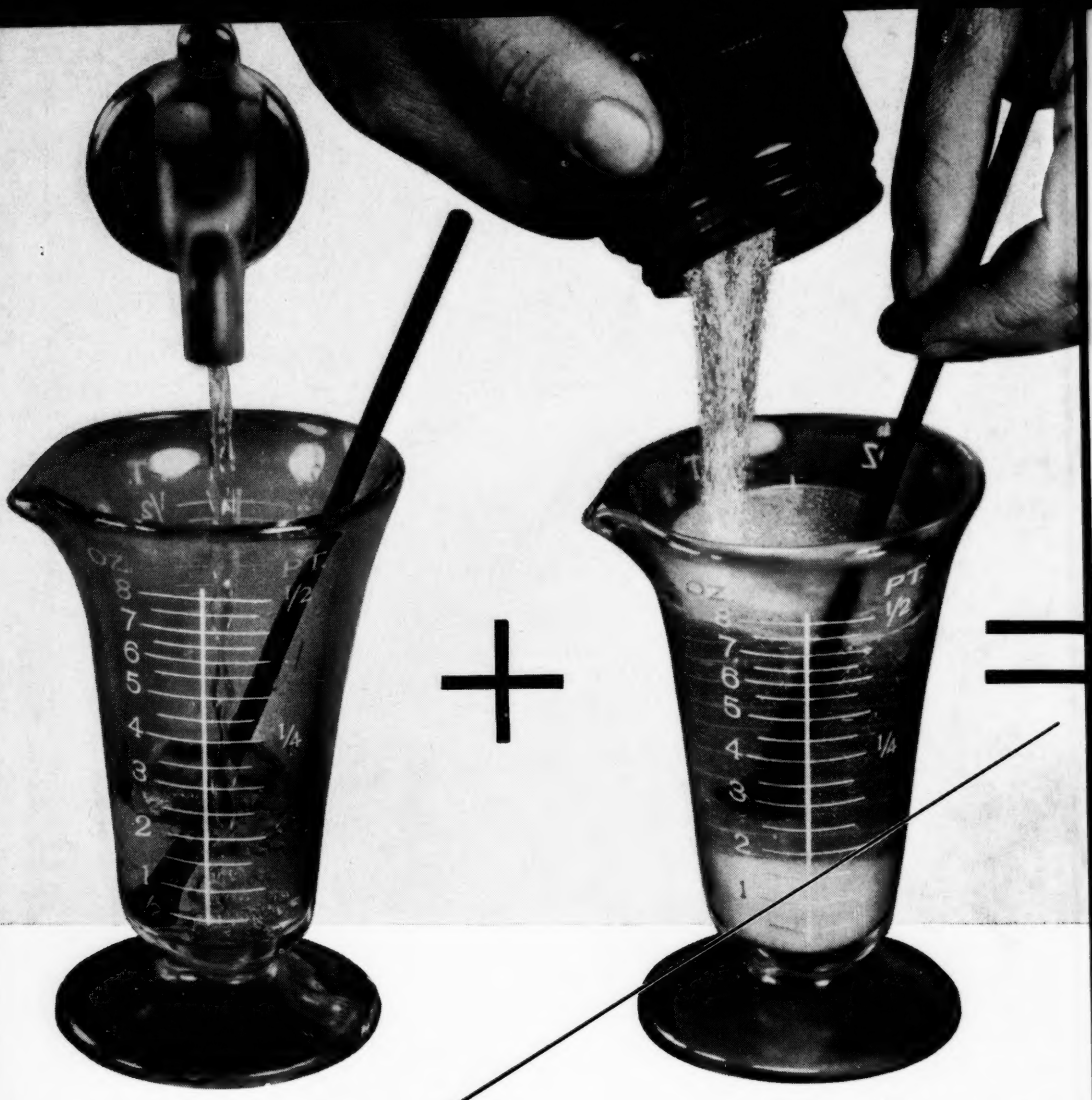

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